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ABSTRACT

Requirements analysis and design for the Ohio Criminal Justice Telecommunications Network are provided in this report on the application in the state of Ohio of techniques developed by the STACOM Project. These techniques focus on the identification of user requirements and network designs for criminal justice networks on a state-wide basis. Techniques for analyzing user requirements include methods for determining data required, data collection, data organization procedures, and methods for forecasting the volume of network traffic. Network design techniques center around a computerized topology program that enables the user to generate least cost network topologies that satisfy network requirements for traffic, response time, and other specified functions. Appendices include the STACOM project state level questionnaire and user agency survey. (Author/CMV)

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State Criminal Justice Telecommunications (STACOM) Final Report

Volume II: Requirements Analysis and Design of Ohio Criminal Justice Telecommunications Network

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FOREWORD

The State Criminal Justice Telecommunications, (STACOM), Project consists of two major study tasks. The first entails a study of criminal justice telecommunication system user requirements and system traffic requirements through the year 1985. The second investigates least cost network alternatives to meet these specified traffic requirements.

Major documentation of the STACOM Project is organized in four volumes as follows:

Title	Document No.
State Criminal Justice Telecommunications (STACOM) Final Report - Volume I: Executive Summary	77-53 Vol. I
State Criminal Justice Telecommunications (STACOM) Final Report - Volume II: Requirements Analysis and Design of Ohio Criminal Justice Telecommunications Network	77-53 Vol. II
State Criminal Justice Telecommunications (STACOM) Final Report - Volume III: Requirements Analysis and Design of Texas Criminal Justice Telecommunications Network	77-53 Vol. III
State Criminal Justice Telecommunications (STACOM) Final Report - Volume IV: Network Design Software Users Guide	77-53 Vol. IV

The above material is also organized in an additional four volumes which provide a slightly different reader orientation as follows:

Title	Document No.
State Criminal Justice Telecommunications (STACOM) Functional Requirements - State of Ohio	5030-43*
State Criminal Justice Telecommunications (STACOM) Functional Requirements - State of Texas	5030-61*
State Criminal Justice Telecommunications (STACOM) User Requirements Analysis	5030-80*
State Criminal Justice Telecommunications (STACOM) Network Design and Performance Analysis Techniques	5030-99*

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*Jet Propulsion Laboratory internal document

This document, No. 77-53, Vol. II, entitled "State Criminal Justice Telecommunications (STACOM) Final Report -- Vol II: Requirements Analysis and Design of Ohio Criminal Justice Telecommunications Network," describes methodologies developed for user requirements studies and for the analysis and design of communication network configurations. It then illustrates the applications of these methodologies in the State of Ohio.

This document presents the results of one phase of research carried out jointly by the Jet Propulsion Laboratory, California Institute of Technology, and the States of Texas and Ohio. The work at the Jet Propulsion Laboratory was performed by the Systems Division, Telecommunications Science and Engineering Division, and Information Systems Division under the cognizance of the STACOM Project. The project is sponsored by the Law Enforcement Assistance Administration, Department of Justice, through the National Aeronautics and Space Administration (Contract NAS7-100).

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

APB	All points bulletin
BCII	Ohio Bureau of Criminal Identification and Investigation
BMV	Ohio Bureau of Motor Vehicles
bps	Bits per second
CCH	Computerized Criminal Histories
CDS	Comprehensive Data System
CJIS	Criminal Justice Information System
CLEAR	Hamilton County, Ohio (Cincinnati) County Law Enforcement Applied Regionally
CRT	Cathode ray tube
DEA	United States Drug Enforcement Agency
DHS	Ohio Department of Highway Safety
FINDER	Calspan Technology Products, Inc., registered trademark for Fingerprint Detector Readers
FBI	Federal Bureau of Investigation
LEAA	Law Enforcement Assistance Administration
LEADS	Ohio Law Enforcement Automated Data System
MDT	Mobile Digital Terminal
NALECOM	National Law Enforcement Telecommunications
NCIC	National Crime Information Center
NCJISS	National Criminal Justice Information and Statistics Service
NILECJ	National Institute of Law Enforcement and Criminal Justice
NLETS	National Law Enforcement Telecommunications System
NORIS	Lucas County, Ohio (Toledo) Northwest Ohio Regional Information System
OBSCIS	Offender Based State Corrections Information System

OBTS	Offender Based Transaction Statistics
OCCA	Omnibus Crime Control Act of 1968
OCH	Ohio Criminal History
ODRC	Ohio Department of Rehabilitation and Corrections
OSP	Ohio State Patrol
PD	Police Department
RCC	Regional Computing Center
RCIC	Regional Crime Information Center
RSC	Regional Switching Center
SEARCH	System for Electronic Analysis and Retrieval of Criminal Histories
SGI	Search Group, Inc.
SIFTER	System for Identification of Fingerprints by Technical Search of Encoded Records
SJIS	State Judicial Information System
SO	Sheriff Office
SPA	State Planning Agency
STACOM	State Criminal Justice Communications
UCR	Uniform Crime Reports

ABSTRACT

Requirements analysis and design for the Ohio Criminal Justice Telecommunications Network is provided in Volume II of the Final Report of a State Criminal Justice Telecommunications (STACOM) project sponsored by the Law Enforcement Assistance Administration (LEAA).

The project has developed techniques for identifying user requirements and network designs for criminal justice networks on a state wide basis. Techniques developed for user requirements analysis involve methods for determining data required, data collection, (surveys), and data organization procedures, and methods for forecasting network traffic volumes. Developed network design techniques center around a computerized topology program which enables the user to generate least cost network topologies that satisfy network traffic requirements, response time requirements and other specified functional requirements.

The developed techniques were applied in the state of Ohio, and results of these studies are presented.

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SECTION 1

SUMMARY

1.1 OBJECTIVES OF STACOM

The State Criminal Justice Communications (STACOM) user requirements study was performed to support the primary STACOM project objective of providing states with the tools needed for designing and evaluating intrastate communications networks. The STACOM project goals are:

(1) Develop and document techniques for intrastate traffic measurement, analysis of measured data, and prediction of traffic growth

(2) Develop and document techniques for intrastate network design, performance analysis, modeling and simulation

(3) Illustrate applications of network design and analysis techniques on typical existing network configurations and new or improved configurations

(4) Develop and illustrate a methodology for establishing priorities for cost effective expenditures to improve capabilities in deficient areas.

To support these overall project goals, and specifically the first, a user requirements task was undertaken to develop and use tools for predicting future criminal justice communications traffic. These tools include techniques of statistical analysis for extrapolating past trends into future traffic predictions, and survey and interviewing techniques for estimating traffic in data types that do not yet exist. The user requirements study was therefore divided into two phases: a study of past trends in existing data types to project future trends in communications traffic for these data types; and a study of new data types that do not yet exist, but which are anticipated, to estimate their future traffic volume.

Network designers then use these estimates of existing and new data types to suggest future intrastate network designs that minimize cost and still satisfy performance requirements. Knowing estimated traffic volumes over a decade, network designers can suggest the best times to upgrade computers or communications lines to keep the performance within the required limits and assure minimum costs.

1.2 TRAFFIC PROJECTION METHODOLOGY AND RESULTS

1.2.1 Existing Data Types

Existing data types contain information primarily used by law enforcement agencies which have been in use typically for several years. These data bases contain files on:

(1) Stolen articles including automobiles, license plates, and other property

(2) Wanted persons

(3) Drivers license information, including driving record and description of driver

(4) Vehicle registration information.

Law enforcement agencies in most states have had access to centralized state data bases containing these file types since the early 1970s. This allows the establishment of historical communication traffic growth patterns and the use of these patterns to project future growth. In the past users have accessed these data files over low-speed communication lines which are defined as 300 bps lines or slower. Many states are now upgrading to high-speed lines which are defined as 1200 bps or faster.

Two causes of past growth of communication traffic into existing data bases have been identified: growth due to communication system improvements, and baseline growth. Communication system improvements that occurred in the two model states were:

(1) Addition of new data bases

(2) Conversion of low-speed communication lines to high-speed lines and new terminal equipment

(3) Addition of new user agencies

(4) Establishment of regional information systems

(5) The use of mobile digital terminals by large municipal police departments.

Baseline growth is the increase in communications traffic that would occur even if there were no communication system improvements and is generally related to:

(1) Increased utilization of existing services

(2) Population and personnel increases

(3) Training.

The first step in our traffic projection methodology was to establish the historical total system traffic growth pattern and to record all past communication system improvements. The second involved the determination of the component of traffic growth caused by past system improvements. This was done by measuring traffic from impacted user agencies or data bases immediately before and immediately after system improvements were made. These increases were short term in nature and were not projected into the future. Baseline growth was calculated in the third step by using the equation:

$$\left(\begin{array}{c}\text{Baseline Traffic}\\ \text{Growth}\end{array}\right) = \left(\begin{array}{c}\text{Total Traffic}\\ \text{Growth}\end{array}\right) - \left(\begin{array}{c}\text{Communication System}\\ \text{Improvement Growth}\end{array}\right)$$

A key assumption of the forecasting technique was that baseline growth in the future will continue as it has in the past. Thus, the fourth step involved using the baseline growth curve established in step three to project future baseline growth. Finally, it is recognized that over the next decade there will be further communication system improvements. The fifth step, therefore, was to identify future expected communication system improvements, their implementation schedule, and their impact on future traffic. The sixth and final step was to combine future baseline growth and growth due to system improvements to obtain future traffic levels into existing data files.

In Ohio, system traffic in early 1972 averaged 32,000 messages per day and increased to 125,000 messages per day by 1976. Of this increase 48,000 messages per day was due to baseline growth and 45,000 messages per day was growth due to communication system improvements. Figure 1-1 shows the Ohio existing data type traffic projections. It is projected that by 1985 traffic into existing data files will be approximately 280,000 messages per day.

1.2.2 New Data Types

New data types consist of those information files which are not now in common use but which are being seriously considered for future implementation. They include:

(1) Law enforcement agency use of a computerized criminal history (CCH) and offender based transaction statistics (OBTS) file, where "law enforcement agency" includes police, sheriff, state police, federal agencies, prosecutors, county jails, and local probation offices

(2) Court use of the CCH/OBTS file for both felony and misdemeanor court processing in the large metropolitan areas of each state

(3) Corrections use of the CCH/OBTS file from the corrections department headquarters and from the penal institutions throughout each state

(4) Use of the CCH/OBTS files by the agencies in each state that administer parole from state institutions, if it is reasonable for that parole agency to participate in the communications network

(5) A state judicial information system (SJIS) for reporting court statistics from the civil and criminal cases of the courts that handle felonies and misdemeanors in the large metropolitan areas

(6) An offender based state corrections information system (OBSCIS) which is a system of files at the headquarters of each state's correctional agency containing information on all inmates in all the state's penal institutions. Portions of these files might be accessible to terminals in the institutions and in the parole agency

(7) Juvenile agency records, if it is reasonable for the juvenile detention agency to participate in the communications network

(8) An automated fingerprint encoding, classification, and transmission system for the large metropolitan areas

(9) Traffic from the states' identification and investigation bureaus for converting manual files on offenders into computerized files, and for entering new offender records that are received manually at the state center.

This traffic in new data types is added to projections of traffic from existing data types to obtain total criminal justice system traffic for the next decade. Network design techniques are then applied to this total traffic volume to design a minimum cost criminal justice information system that meets the performance requirements.

New data type traffic forecasts were made using a combination of estimates from operators and users of the present criminal justice communications systems in each of the states, and using extrapolations based on recent history. The new data types were divided into three basic types for purposes of projecting future traffic: (1) Arrest-dependent traffic such as transactions with the CCH/OBTS files which originate at law enforcement agencies, courts, correctional institutions, probation and parole agencies, prosecutors, and federal offices, and including automated fingerprint traffic; (2) Offender-related traffic such as that associated with an OBSCIS system in adult correctional institutions or with juvenile agency traffic; (3) Traffic whose volume is determined by other factors, such as that in an SJIS system which would be determined by court activity, or traffic from a state data center devoted to converting manual records to automated files.

Arrest dependent traffic was estimated by determining the number of offenders through each step of the states' criminal procedures and then projecting the number and types of messages that would be generated at each step of the procedure. Summing these information needs over the procedural steps carried out by a particular agency then yielded the total message volume generated by that agency as a function of the number of arrestees through the process. The approach of assigning information needs to the several steps of a state criminal procedure

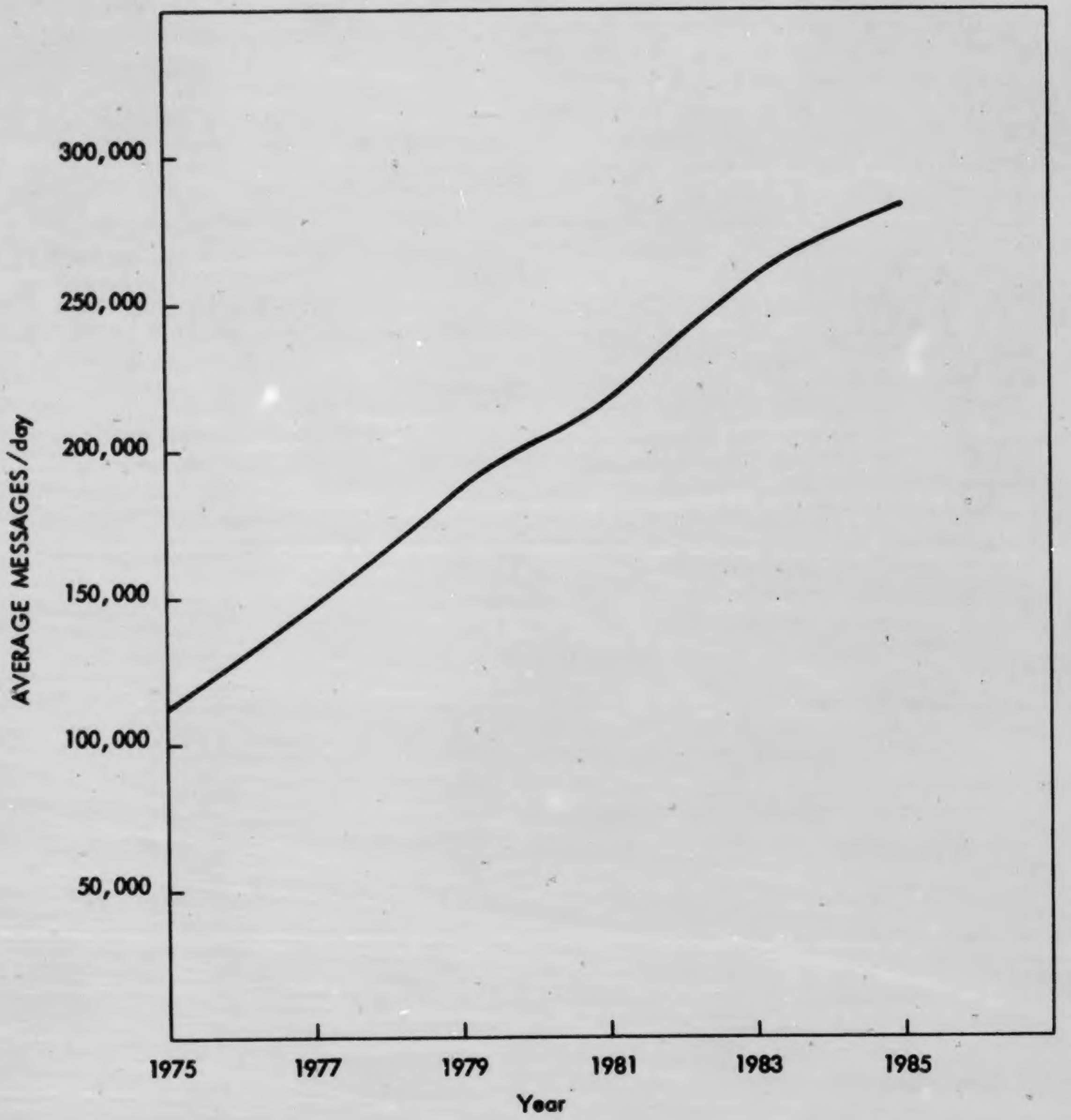


Figure 1-1. Ohio Projected Existing Data Type Traffic Growth

was first suggested for this project by Bill Griffith of the Ohio Department of Computer Services. This technique was applied to both CCH/OBTS traffic from all criminal justice agencies and to automated fingerprint traffic from law enforcement agencies. CCH/OBTS traffic was allocated to user terminals according to the total FBI index crime in each law enforcement jurisdiction. Court usage was prorated according to the population or court activity in the largest metropolitan areas. Correction usage was distributed according to the number of inmates in the several institutions, and only the headquarters of the parole agency was allocated traffic if that office was a user of the CCH/OBTS files. Automated fingerprint traffic was distributed to the large metropolitan areas according to the population of each city or according to the total FBI index crime in each metropolitan area.

Offender-dependent traffic includes an OBSCIS system for each state's correctional institutions and, if anticipated by the states, a youth agency data system. Traffic was computed by assuming that an inquiry and a file update were generated for every inmate or student in the state institutions every few weeks, and that, if the parole agency had access to an appropriate part of the system, it would also generate inquiries on a regular basis. The estimate of transaction frequency was derived from conversations with correctional institution information system officials who described past experience and provided future estimates of traffic volumes. Traffic was distributed between the institutions according to the number of inmates or students in each facility.

Other types of traffic include an SJIS system, which would produce traffic dependent upon the level of court activity, and data conversion traffic from the state data center, which would depend on the number of employees in such a center and on the volume of records requiring conversion and updating. SJIS traffic was estimated by assuming that only statistical information would be transmitted on state networks and that one message would be generated for each criminal or civil disposition in the courts of the largest metropolitan areas. SJIS traffic was distributed according to the population of metropolitan areas, or according to the volume of dispositions, whichever provided the best statistics. Although an assumption was made throughout the study that criminal activity and communication traffic will increase each year, data conversion traffic was kept constant because it was also assumed that inquiries and file updates will gradually come from remote user terminals rather than from a central state investigative agency.

This analysis suggests that new data traffic in Ohio will increase from an early 1977 value of about 14,000 messages per day to 170,000 messages per day in 1985. The large increase in Ohio traffic is based on the assumption that recent legislative bills requiring state reporting of both felony and misdemeanor arrests will be enacted, and that traffic will be much higher than if only felony arrests were reported. Local agencies are understood to be opposed to this legislative request because of the increased workload it would impose, but its passage was assumed so that the system was conservatively designed to handle this increased traffic if it should appear on the network. New data traffic growth for Ohio is shown in Figure 1-2.

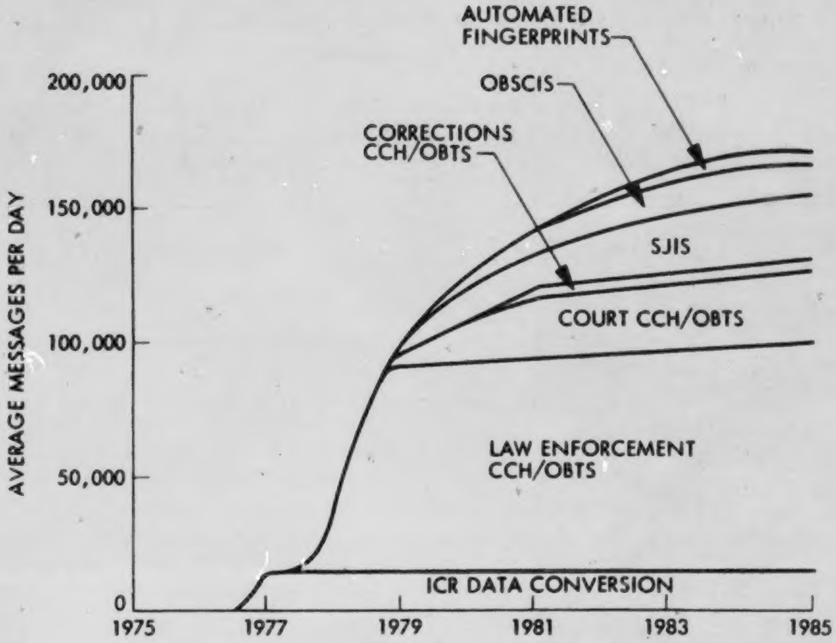


Figure 1-2. Ohio New Data Traffic Growth

1.2.3 Existing and New Data Type Traffic Projections

The existing data type traffic volume of Section 1.2.1 and the new data type traffic volume of Section 1.2.2 were added to obtain the total estimated traffic volume for the study period as shown in Table 1-1 and in Figure 1-3. The derivation of these total traffic volumes is described in Section 5. For the purposes of this summary, it is sufficient to note that, in addition to merely adding the traffic volumes of new and existing data types, the total system traffic was modified to account for a slowing of traffic growth whenever the volume reached a level close to the system's computer capacity, and for a similar brief period of slow growth followed by an accelerated growth period immediately after a computer upgrade. Note that, although existing data type traffic exceeds new data traffic volume throughout the period of this study when measured in units of average messages per day, new data volume far exceeds existing data traffic toward the end of the study period if volume is converted to peak characters per minute. This dominance is caused by the longer message lengths of the expected new data types. Note also that between 1977 and 1985 this study projects about a threefold increase in Ohio's traffic measured in average messages per day, and a fivefold increase in demand in terms of peak characters per minute. If existing data traffic continues to increase as it has in the past, and if new data types are implemented at the rate state planners hope they will be, state communication system operators and data system planners should prepare for a continuing program of upgrades to terminals, lines, switchers, and central processors. The necessity of such a program is apparent in Ohio and it is likely that many other states are in a similar growth situation.

1.3 SUMMARY OF NETWORK DESIGN GENERAL METHODOLOGY

Six major activities were carried out in the network design phase of the study. These activities are summarized in the following paragraphs:

1.3.1 Definition of Analysis and Modeling Techniques

A task was undertaken to define and develop specific analysis and modeling tools for general use in intrastate systems. The principal tool developed is the STACOM Network Topology Program. This program, written in FORTRAN V and implemented on a UNIVAC 1108 computer under the EXEC-8 operating system, enables a user to find least cost multidropped statewide networks as a function of traffic level demands and other functional performance requirements.

The major inputs to the program are:

(1) Traffic levels at each system termination on the network

(2) Desired response time at network system terminations

(3) Line tariff structures

(4) Locations of system terminations using Bell System Vertical-Horizontal (V-H), coordinates

(5) The number of desired regional switching center, (RSC), facilities. RSCs serve system terminations in their defined regions and are interconnected to form total networks.

Table 1-1. Total Statewide Criminal Justice Information System Traffic in Ohio

Traffic Summary: Average Messages per Day.

Year	Existing Law Enforcement Traffic	New Data Type Traffic	Total Statewide Traffic
1977	147,200	14,300	161,500
1979	188,800	99,500	288,300
1981	213,500	142,300	355,800
1983	255,800	163,500	419,300
1985	281,200	170,300	451,500

Traffic Summary: Peak Characters Per Minute.

Year	Existing Law Enforcement Traffic	New Data Type Traffic	Total Statewide Traffic
1977	23,720	10,960	34,680
1979	30,420	69,240	99,660
1981	34,400	103,560	137,960
1983	41,200	121,720	162,920
1985	45,300	127,250	172,550

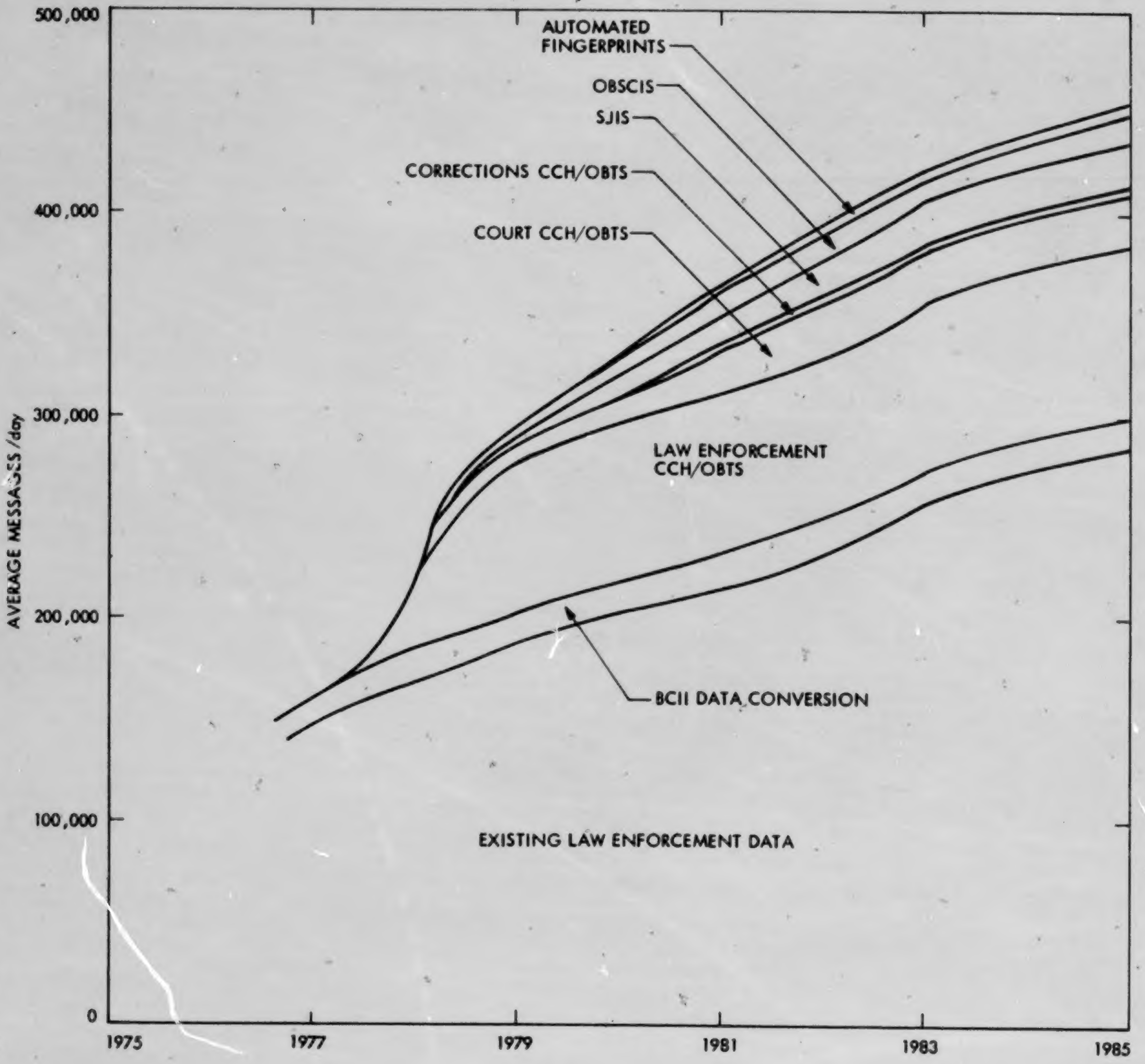


Figure 1-3. Ohio Statewide Criminal Justice Information System Traffic Projection in Average Messages per Day

Principal outputs of the topology program are:

(1) Line capacities and layouts servicing system terminations

(2) Fixed and annual recurring costs for lines, modems, service terminals, etc. RSCs are priced separately.

(3) Line performance characteristics such as line utilizations and mean response times

A second major analysis technique enables network designers to determine the reliability and availability of network configurations produced by the topology program.

Finally, a network response time model used in the topology program, is also useful in understanding present and future performance requirements for switching and/or data base computers in the network. This is true because the response time model involves a queueing analysis which includes queueing times encountered at computer facilities.

Descriptions of these design and analysis tools are presented in more detail in Section 7 of this report.

1.3.2 Network Functional Design Requirements

At the completion of state system surveys, and after sufficient interaction with state planning personnel, and prior to any specific network design activity, a document was produced specifying Network Functional Design Requirements. This document provides network performance criteria which are to be met in subsequent designs. The Functional Requirements specify what the network must do, and do not address at this level the specifics of how requirements are to be met.

The network Functional Requirements for Ohio are presented in Section 10.

1.3.3 Analysis of Existing Networks

This task employed developed design and analysis tools to determine the extent to which existing statewide networks conform to State Network Functional Requirements. Areas of discrepancy are noted and discussed. Results for Ohio are summarized later in this Section. A detailed discussion is presented in Section 11.

1.3.4 Generation of New or Improved Networks

After specific studies of interest were identified with state personnel, STACOM design and analysis techniques were employed to study statewide network configuration alternatives, (options), and additional cost impact studies of interest.

In the State of Ohio, four basic network options were considered for the LEADS system. These involved determining cost and performance measures under the Multi-Schedule Private Line, (MPL), tariff for LEADS configurations employing from zero to three RSCs in addition to the switcher/data base facility in Columbus. The four options were:

Option 1 - switcher/data base located in Columbus (one region).

Option 2 - switcher/data base located in Columbus plus an RSC in Cleveland (two regions).

Option 3 - switcher/data base located in Columbus plus RSCs located in Cleveland and Cincinnati, (three regions).

Option 4 - switcher/data base located in Columbus plus RSCs located in Cleveland, Cincinnati and Toledo, (four regions).

Four more network options were studied in Ohio involving the possible integration of BMV and New Data Networks with the LEADS Network. These options were:

Option 5 - costs for maintaining separate LEADS and BMV networks.

Option 6 - costs for integrating the LEADS and BMV networks into a single network.

Option 7 - costs for maintaining separate LEADS and New Data networks.

Option 8 - costs for integrating the LEADS and New Data networks into a single network.

Two additional network performance studies carried out in Ohio included consideration of LEADS network cost increases as terminal response time requirements are reduced, and an inquiry into the impact on network cost and performance due to adding digitized classified fingerprints as a traffic type to the LEADS system.

1.3.5 Software Documentation

A final task carried out was the documentation of the STACOM Network Topology Program in the form of a users guide. This document, No. 77-53, Vol. IV, is entitled, "State Criminal Justice Telecommunications (STACOM) Final Report - Volume IV: Network Design Software Users' Guide."

1.4 SUMMARY OF NETWORK DESIGN STUDY RESULTS

The study results itemized below are discussed in more detail in Section 13 in this report. The following summary lists the principal findings of interest for each of the studies carried out.

Ohio Study Outcome

- The least cost LEADS Network is a single region configuration with a switcher/data base facility located in Columbus. The line savings due to the use of one, two or three additional regional switchers do not offset increased costs for regional switcher hardware, sites, personnel, interregion lines and increased engineering costs.

- The STACOM optimized single region LEADS network is less costly than continuation of the present LEADS system over a period of eight years by approximately $2,850,000. This cost differential considers user terminal and line costs only. Columbus switcher/data base costs are not included. The new network also meets all STACOM/OHIO Functional Requirements.

- Response time goals listed in the STACOM/OHIO Functional Requirements are not met in the existing system on low speed lines, and on high speed lines during periods of network peak loading.

- There are no meaningful network cost savings to be realized through the integration of the LEADS and BMV systems if the integrated network is priced with the MPL interstate tariff. A meaningful cost savings can be realized if the integrated network is priced under an intrastate tariff.

- There are no significant cost savings to be realized through the integration of New Data Types into the LEADS network over maintaining separate networks.

- Digitized classified fingerprint data can be added to the LEADS network as specified in this report without compromising performance of the STACOM/OHIO LEADS System.

- LEADS network response time requirements for the STACOM/OHIO single region case can be reduced from 9 to 7 seconds before additional costs are incurred. Reduction to 6 seconds increases annual line costs approximately 2%. Reduction to 5 seconds increases annual line costs approximately 13%.

- The mean service time per transaction in the Columbus switcher/data base computer should be immediately reduced to 470 ms. In 1981 the required mean service time per transaction is 425 ms and in 1985 340 ms is required in order to meet functional requirements for traffic growth. A 4 x 4 processor (4 central processing units) configuration is called for in 1981.

SECTION 2

SYSTEM DESCRIPTION

2.1 GENERAL

Many states already have sophisticated criminal justice communications systems and are continually working to upgrade them. This upgrade process includes modifications to anticipate increased traffic and the addition of new files to make the systems more useful to criminal justice agencies. Ohio is doing exactly this; it already has several data systems for law enforcement and criminal justice agencies with steadily increasing traffic, and it is considering system improvements to user terminals, line speed, and central computers. State planners keep informed and look forward to the day when some of the new data types suggested in this report may be included in the files of their state's system.

In this report, the central state files of existing data types were assumed to include such items as:

- Wanted persons
- Outstanding warrants
- Stolen vehicles
- Stolen license plates
- Drivers licenses
- Vehicle registrations

New data types that might be added during the period of the study included:

(1) Law enforcement use of state CCH/OBTS files

(2) Court use of CCH/OBTS files

(3) Corrections use of CCH/OBTS files

(4) Parole agency use of CCH/OBTS files

(5) A state judicial information system

(6) An offender-based state corrections information system

(7) An automated fingerprint encoding, classification and transmission system

(8) State investigation bureau data conversion traffic

Most of these files were assumed to be located at a central state data center, although it is up to each state to organize the control of its files. In some states, for instance, it might be desirable to keep control of corrections agency files within correctional organizations rather than maintaining them with other state data bases. States will also vary in the distribution of terminals, lines, computers, and switchers. A schematic representation of a state communication system is shown in Figure 2-1, and a diagram of the facilities making up such a system is shown in Figure 2-2. These figures will assist in clarifying the description of the Ohio data bases, facilities, users, and functions in the remaining portions of this section.

2.2 SYSTEM DESCRIPTION

For the purposes of this study, the Ohio criminal justice telecommunications system includes the present LEADS system with all its data bases and existing terminals, any new terminals that might be added to the LEADS system, terminals in courts to support the CCH/OBTS and SJIS functions, terminals in the Ohio Department of Rehabilitation and Corrections (ODRC) for the ODRC's use of the CCH/OBTS files and for an OBSCIS system, and several terminals in the offices of the Ohio Bureau of Criminal Identification and Investigation (BCII) for converting manual records to computer input. One of the options studied for network optimization purposes also includes all the terminals in the Ohio Bureau of Motor Vehicles (BMV) throughout the state.

The system does not include terminals connected to local computers which contain strictly local data bases. For instance, in the Lucas County Northwest Ohio Regional Information System (NORIS) surrounding Toledo, law enforcement agencies and courts have terminals tied into a local computer, but the individual terminals are not included in the state system, as defined in this study, since the state-level termination is taken to be the local computer. The many local terminals have access to the state files through the local computer, but for purposes of traffic distribution on the state network, the termination is taken as the local computer. Similarly, the County Law Enforcement Applied Regionally (CLEAR) system in Hamilton County surrounding Cincinnati, is another regional system with many terminals tied to it, but the local terminals are invisible to the state system since the termination for state traffic projections is the local CLEAR computer.

2.2.1 Data Bases

All of the data bases in the state criminal justice telecommunication system are located in Columbus. The present Ohio criminal justice data center contains records on wanted persons, stolen vehicles, and stolen license plates. It also will contain a large CCH file in the near future, which is treated as a new data type because it has not yet been made available to the users of the LEADS system, and because in the future it might become the nucleus of an expanded CCH/OBTS system with many more data elements.

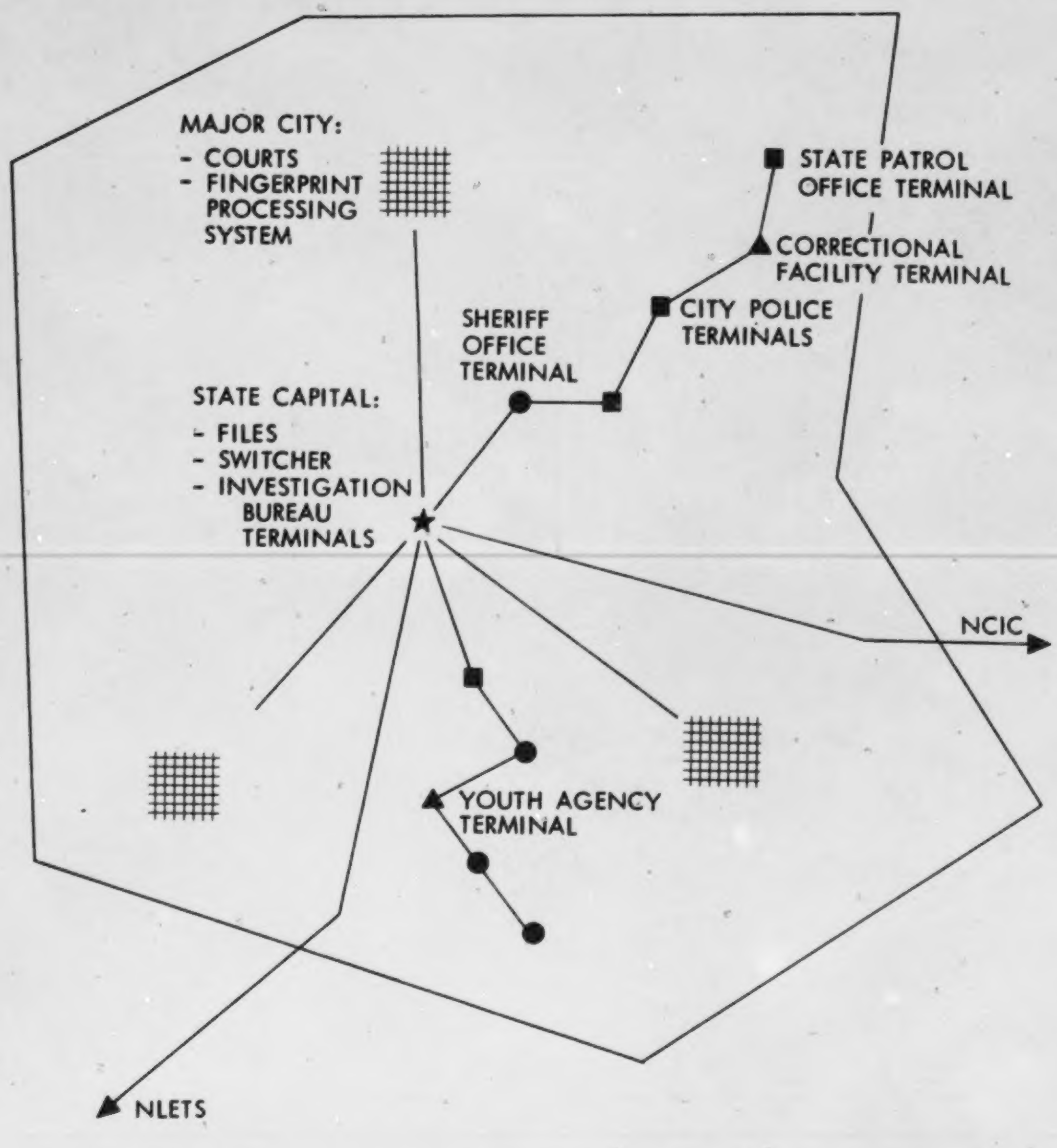

MAJOR CITY:
- COURTS
- FINGERPRINT PROCESSING SYSTEM
STATE PATROL OFFICE TERMINAL
CORRECTIONAL FACILITY TERMINAL
CITY POLICE TERMINALS
SHERIFF OFFICE TERMINAL
STATE CAPITAL:
- FILES
- SWITCHER
- INVESTIGATION BUREAU TERMINALS
NCIC
YOUTH AGENCY TERMINAL
NLETS

Figure 2-1. State Communication System Schematic

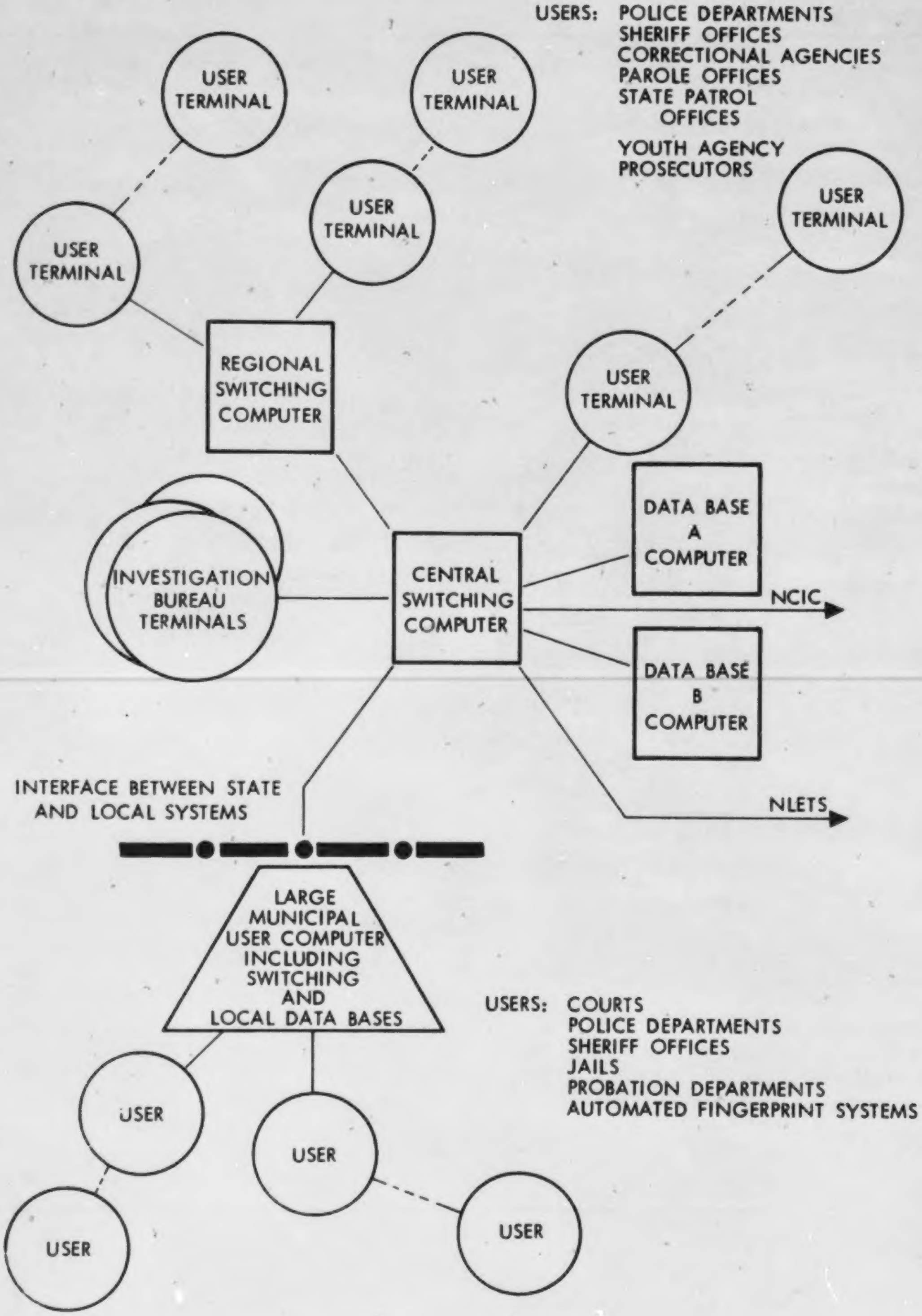

USERS: POLICE DEPARTMENTS
SHERIFF OFFICES
CORRECTIONAL AGENCIES
PAROLE OFFICES
STATE PATROL OFFICES
YOUTH AGENCY
PROSECUTORS
USER TERMINAL
USER TERMINAL
USER TERMINAL
USER TERMINAL
USER TERMINAL
USER TERMINAL
REGIONAL SWITCHING COMPUTER
INVESTIGATION BUREAU TERMINALS
CENTRAL SWITCHING COMPUTER
DATA BASE A COMPUTER
NCIC
DATA BASE B COMPUTER
NLETS
INTERFACE BETWEEN STATE AND LOCAL SYSTEMS
LARGE MUNICIPAL USER COMPUTER INCLUDING SWITCHING AND LOCAL DATA BASES
USERS: COURTS
POLICE DEPARTMENTS
SHERIFF OFFICES
JAILS
PROBATION DEPARTMENTS
AUTOMATED FINGERPRINT SYSTEMS
USER
USER
USER
USER

Figure 2-2. State Communication System Facilities

Also located in the data center are files of the BMV which contain records on all licensed drivers and motor vehicles in the state.

New data types include, in addition to the BCII CCH file, data bases required for the systems summarized in Section 2.1. These are:

(1) Statistical data kept by the Administrative Director of Courts in the Ohio Supreme Court for the SJIS system. If an on-line system connecting the large metropolitan courts to the Supreme Court data base were established, the files would likely be kept in Columbus.

(2) The files maintained by the Ohio Department of Rehabilitation and Corrections (ODRC) at its headquarters which would make up the OBSCIS system.

(3) New automated fingerprint files kept by the BCII in Columbus. These automatic files would be kept in a file separate from, but similar to, the manual fingerprint file presently maintained by the BCII.

2.2.2 Users

The users proposed for the Ohio criminal justice information system include all of the present users of the LEADS system, any expansion of that system to counties or agencies which would like to participate, and other criminal justice institutions which have, up to now, not had computerized information systems available to them or which had their own dedicated machines, but which were not tied into a statewide system. These additional users are listed in Section 2.1 but are summarized below for completeness.

(1) The law enforcement users of the LEADS system are primarily the local police departments and sheriff offices throughout the state. In addition, Ohio State Patrol (OSP) offices are tied in, as are several federal law enforcement, military, and investigatory agencies. In the larger cities such as Cleveland, Cincinnati, and Toledo, the user is a large computer installation provided by the city or county, with individual terminals in the local offices connected to the central local computer. To the statewide network, the terminal appears as a very large single user, when it really is up to several hundred users on the other side of a single computer.

(2) The proposed statewide system would include the courts in the appellate judicial districts surrounding the six largest metropolitan areas. These users would include both courts of general and limited jurisdiction and would apply to both criminal and civil court activity. The statewide network would allow the courts to inquire into or update the CCH/OBTS files, and it would allow

the courts to send their statistics automatically to the Supreme Court for inclusion in the SJIS system. The complete SJIS system would provide the calendar management and court records functions at the local level within the largest appellate judicial districts but on a statewide level it would only provide a court statistics capability.

(3) The ODRC would be connected to the statewide criminal justice information system under this proposal, to allow the eight ODRC institutions to obtain information and update state records in the CCH/OBTS files and to communicate with the ODRC files in Columbus to obtain information on inmates from the OBSCIS system.

(4) Law enforcement agencies in the largest metropolitan areas would already be users of the statewide system, but the new automated fingerprint data would be added to their traffic in future years. This use would consist of both fingerprint cards that had been automatically encoded and classified, and latent prints for search and matching during an investigation.

2.2.3 Facilities

The facilities of a statewide Ohio criminal justice information system which would include both existing and new data types would be an expanded version of the present LEADS system. The LEADS system includes the criminal justice data base in Columbus, lines and modems to communicate with the users, and terminals in the user agencies. The BMV network includes a separate system of lines, modems and terminals in BMV offices with users having access to the drivers license and vehicle registration files of the criminal justice data base. Computer installations are located at the data bases and in the large cities and counties where they serve as the termination of the statewide system and as a central switcher and data base for hundreds of local terminals which can access the state system through this local computer.

An expanded statewide system including new data types would have more individual terminals as local agencies come to depend on the speed and utility of the state system. The detailed design of a statewide system, including cost trade-offs to minimize network and computer costs, is described in the network design and performance analysis phase of this report. The SJIS systems run by the courts in the appellate judicial districts surrounding the six largest metropolitan areas would each likely require a computer with terminals in the individual courts, since it is anticipated that the SJIS systems would be local court record keeping installations with only statistics sent on to the Supreme Court in Columbus. Additional lines and modems would be required for connecting these local SJIS installations into the statewide system.

Similarly, the ODRC would require a computer in Columbus with terminals in the eight remote institutions to operate an OBSCIS system.

This computer could be a portion of the LEADS system with a separate data base, or it could be an entirely separate machine with its own data base which is dedicated to the ODRC. ODRC headquarters already has a LEADS terminal, and it will likely only be a short time before ODRC has access to the state CCH files. Terminals in the institutions are several years away, and it would take this development before a true OBSCIS system could be established. The Ohio parole system is under the jurisdiction of the ODRC so parole records are available to the parole agency management. It is not likely that terminals will be placed in local parole offices since parole officers would likely be able to use a nearby police or court terminal for an inquiry or update that was required.

2.2.4 Functions

The statewide Ohio criminal justice information system discussed in this report serves a multitude of functions by providing all criminal justice agencies with easily and rapidly accessible data in a wide variety of categories. Data files maintained in the state criminal justice data base contain information on:

- Wanted persons
- Auto alert files
    - Stolen vehicles
    - Vehicles involved in felonies
    - Stolen license plates
- Drivers licenses
- Vehicle registrations
- CCH files

In addition to these files, users can access a national data base located in Washington, D.C., via the state system. This National Crime Information Center (NCIC) is operated by the FBI. NCIC files are:

- Stolen vehicles
- Stolen articles
- Wanted persons
- Stolen securities
- Stolen guns
- Stolen boats.

Finally, users can send and receive messages to and from other states over the National Law Enforcement Telecommunications System (NLETS) which consists of only communication lines and a switcher. NLETS has no data base. Messages to other states first travel via the state system to Columbus where they are switched onto the NLETS system.

This report suggests that in the coming decade the existing CCH files in the BCII will be expanded to include a complete CCH/OBTS system so that offenders are tracked throughout their criminal careers by all criminal justice agencies. For purposes of estimating traffic over such a system, it is assumed that this expanded CCH/OBTS file will be made available to a larger group of users, including more local city and county police agencies, the courts in the large appellate judicial districts, and the ODRC and its institutions throughout the state. The functions to be performed by this system are really limited only by the imagination of the individual user agency and the local terminal operators. Data on a wide variety of topics are made available to users in a matter of seconds, and user resourcefulness is the limiting factor in determining the functions to be performed.

Besides assuming a continuation of the existing files, and an expanded CCH/OBTS data base with more users, this report estimates future traffic on the assumption that several more new data types will be added to the system in the next decade, along with the appropriate users. These new data types and users are described in the sections above, and the functions performed by the system are again limited primarily by the imagination of the user and the operating agency.

For instance it is assumed that the SJIS system, which is estimated to be started on an experimental basis in a single judicial district, but which is not projected to be in use throughout the state until the 1980s, will be used on a local level for court management, case tracking, and calendar scheduling in both criminal and civil cases. None of this business would appear on state lines, however, since state reporting would be confined largely to statistical record keeping.

The Ohio Department of Rehabilitation and Corrections does not presently have access to the BCII CCH files, nor is there an on-line OBSCIS system operating. However, within the next decade it is projected that both of these functions will be provided in the Ohio criminal justice communication system.

Gradually, as automated fingerprint systems become standardized, less experimental, and less costly, it is expected that Ohio will begin to implement such systems, at least in the large metropolitan areas where fingerprint volumes justify the expense of the equipment. The statewide telecommunications system would function to transmit both encoded and classified 10-print cards and encoded latent prints found in an investigation. Fingerprint card information would then be filed, and the files could be searched automatically for prints to match latents.

In addition to providing access to a centralized data base, the state criminal justice system allows transmission of messages between users. Administrative messages can be sent from one user agency to another or an "all points bulletin" message can be sent from one agency to many other agencies. These messages are free form in format and do not require data base searches.

SECTION 3

TRAFFIC GROWTH MODELING - EXISTING DATA TYPES

3.1 APPROACH

Determining future communication traffic levels is of primary importance in assessing the users' needs of a state criminal justice telecommunication system. Future communication traffic levels into existing data files were estimated by examining available past growth trends, and projecting these trends forward. There were two components to past traffic growth: growth due to communication system improvements, and growth due to increased user demand. It was assumed that growth due to increased user demand would continue into the future as it has in the past. Growth due to communication system improvements can be characterized as short term rapid increases and thus it would be inappropriate to project these increases forward. We have instead predicted implementations of future communication system improvements and their impact on traffic levels. Our estimates of these two components of traffic growth are combined to form the prediction of total future communication traffic levels into existing data types.

Once total communication traffic levels are known we must determine the distribution of traffic across all locations in the state. This involves the identification of the paths of general traffic flow as well as a quantification of the number of messages to and from each system user. Models were developed that correlated current traffic levels with user characteristics. These models were then used to determine future traffic distributions.

3.2 DATA GATHERING TECHNIQUES AND RESULTS

In order to perform this analysis, information is needed from the model states concerning current and past network configurations, record types, traffic volumes, message lengths, traffic distributions, operating procedures, user agency characteristics, and planned upgrades. Five years of past data were collected.

Two survey forms were developed to obtain this information. A state level questionnaire was written and given to the communication system planner in the state planning agency. This survey form is shown in Appendix A. The survey was directed to the proper persons in the Ohio state government. We obtained answers to our questionnaire from the Ohio State Patrol and the Law Enforcement and Programming Division of the Department of Computer Services.

As seen in Appendix A we began by asking state planners to provide one diagram showing principal components used in information interchange between all criminal justice user agencies. Principal components were defined as:

Data bases

Switchers/concentrators

Terminals

Communication lines

Data bases only included those computers containing records that could be accessed by communication lines considered part of the state information system. We also asked for communication line sizes in bauds which measures the rate that information can be loaded on and taken off communication lines. Finally we asked state planners to identify changes to the above diagram and indicate when these changes were made. Answers to these questions provided a knowledge of current and past network configurations. In general, this information was available.

The second question on the state survey asked for more specific information concerning data bases. We asked for the type and number of records available to system users from 1971 - 1976. A minimum of five years of past traffic statistics were needed to establish past growth trends. Again, Ohio provided us with answers to this question.

The third question asked for traffic volume data. We requested monthly communication traffic volumes in units of average messages per day by user agency and message type. The time period was again January 1971 - 1976. Ohio had complete statistics back to 1971; however, due to inconsistencies between IBM and UNIVAC statistical packages there were discrepancies in the definition of a message before and after the Spring of 1975.

The fourth question asked state planners to provide average message lengths by message type. As a check of these numbers, we also asked to see format details for all message types transmitted over the state criminal justice telecommunications system. Ohio responded to this question by providing us with a copy of their operating manuals which presented formats required to obtain access to the files. Combining knowledge of message formats with a knowledge of the message type volume distribution allowed us to calculate an average message length.

Question five asked for an origin and destination matrix showing yearly message volume from each user agency to each other user agency in the state. Ohio could not provide this information.

The sixth question asked about operating policies that affect traffic volumes. Specifically we asked whether queries into one data file automatically generate queries into other data files and whether there were record update requirements. No answers were obtained to the second question; however, information was provided on automatically generated messages.

Finally we asked state planners to inform us of any planned upgrade that would affect traffic against current law enforcement files. We listed examples such as:

(1) An increase in the number of records in a file

(2) A reduction in response time

(3) An increase in the number of user agencies.

Ohio provided a complete response to this last question.

The second form designed for the collection of information was the User Agency Questionnaire. (See Appendix B.) This questionnaire was intended to obtain information on user characteristics, on current and desired response time and to obtain from the users an estimate of their current traffic levels. This last item was intended to be a check of similar data requested from the state. User survey forms were sent to all user agencies in Ohio. Many, but not all, agencies completed the survey and returned it to us.

As seen in Appendix B user agencies were asked to supply traffic data in the form of the average number of messages sent per day on the state system, the average number of messages received per day on the state system, and the number of messages sent during a peak hour on the state system. Responses were generally consistent with state statistics which were most likely the data source used by the respondents.

Users were next asked for current average response times and acceptable response times. Almost all agencies answered these questions with acceptable response times slightly lower than actual response times.

Finally, user agencies were asked to supply data on the crime rate per capita in their area and the number of personnel requiring information over the state criminal justice telecommunications system. Five years of this information was requested; most agencies supplied it for the current year but did not give historical data.

Because a number of agencies did not respond to the user surveys, other sources of data were identified that could fill information gaps. Uniform crime report data were obtained for Ohio. This report presented population and crime statistics for all law enforcement agencies in the state. We also used the national Uniform Crime Reports issued annually by the FBI (Crime in the United States) to obtain information on the number of personnel employed by each agency.

In addition to survey forms and statistical tables, we conducted personal interviews to collect data necessary for predicting future traffic levels into existing data files. Interviews were conducted with data processing personnel in the larger metropolitan police departments and with persons representing regional information centers. Personal interviews were conducted with these representatives because of the large volume of traffic originating from metropolitan police departments and regional information systems. We asked questions concerning present methods for accessing state data files, future communication plans that would impact communication traffic into the state system, accessibility of information contained in regional data bases to other users of the state system, data types maintained on regional systems, and operating procedures that automatically generate messages from regional data bases into the state data base. We found that on-site interviews were required in some instances; however, we were able to interview a number of these agencies by telephone. Both the large police departments and regional information centers were cooperative and provided the required information.

All the above data were used in our traffic growth and distribution models which will be discussed in following sections.

3.3 ANALYSIS METHODOLOGIES APPLIED TO TRAFFIC STATISTICS

3.3.1 Definitions

Traffic statistics were obtained primarily from the operating agencies of the existing state criminal justice telecommunication systems. The form of the data used to project future growth was monthly message volumes broken out by system users. In examining the data, care had to be taken in interpreting the numbers given and in defining carefully the parameters to be measured.

There are two measures of system traffic that will affect final system design. The first is the number of communication messages transmitted over the system. A communication message is defined as the transmission of information between a sender and a final receiver. For example, when a user is attempting to obtain a record contained in a data base, the sender is considered to be the user and the final receiver is considered to be the data base. Independent of the path of the message, the transmission of the data base query between the user and the data base constitutes one communication message. Once the computer's files have been searched and a response prepared, the transmission of the response from the data base back to the user constitutes a second communication message.

The second measure of traffic affecting system design is the number of transactions handled by the computer. A transaction is defined as the processing by the computer of a request for service. Requests for service include data base searches and preparation of response, data base record modifications, and switching of messages. It is possible for one message into the computer to generate more than one transaction. For example, if a query into the state wants/warrants file automatically generates a message to the national wants/warrants file then two transactions occur: the state wants/warrants data base search and the switching of the inquiry to the national file.

From the definitions above, it is apparent that communication messages demand communication line services while transactions demand computer services. Methods of estimating these parameters from available statistics will be discussed next.

3.3.2 Interpretation of Communication Traffic Statistics

In examining available traffic statistics, the analyst must first determine whether traffic is a measure of communication messages or transactions. If it is established that communication messages are being counted, then a knowledge of computer message handling procedures allows the calculation of computer transactions. Likewise, if it is established that transactions are being measured, then a knowledge of computer message handling procedures will generally allow the calculation of communication message volumes. When it is not clear whether transactions or messages are being counted the analyst must test both hypotheses. Generally by looking for internal consistency or by checking with other independent traffic statistics, it is possible to determine if transactions or messages are being measured.

It is common for statistics gathering routines to record the number of communication messages sent and received from every component of the communication system. Thus a message sent from a user terminal to a data base is recorded as being sent from the user terminal and received by the data base. When total system messages are calculated by summations of messages over all components, this leads to a double counting of messages. Dividing by a factor of two leads to the true message count.

Determination of the number of messages sent from the state system to national communication systems must be handled with care. There are currently two national communication systems, the National Crime Information Center (NCIC) and the National Law Enforcement Telecommunication System (NLETS). The NCIC services data base queries and updates but has no message switching capability. The data base is located in Washington, D.C. NLETS provides message switching capabilities tying together state data bases, but it maintains no data base of its own.

Messages sent from state telecommunication users to the NCIC data base can be generated in two ways. The first involves a direct message between the user and NCIC where the state user utilizes required NCIC formats. The second, and by far the most common, results from a user sending a message into the state computer which then automatically forwards it to the NCIC stolen article file.

Messages into the NCIC data base must travel from the user to the state switching center and from the state switching center to the NCIC data base. Responses then retrace this path back to the user. Communication messages to and from the NCIC should be counted in the following way (see Figure 3-1):

(1) The initial transmission from the user to the state switching center should be counted as a separate NCIC communication message only if it is a direct message between the user and NCIC.

(2) All transmissions of the data base queries and updates between the state switching center and NCIC should be counted as communication messages.

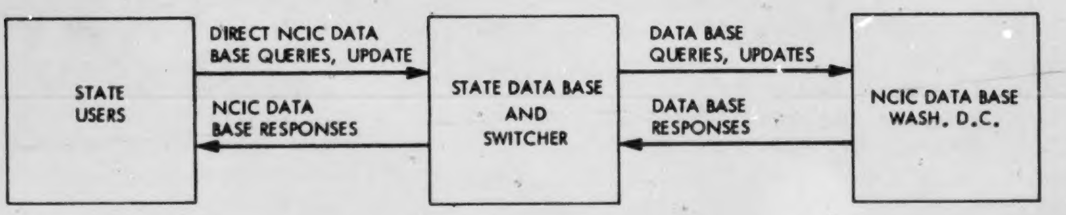

STATE USERS
DIRECT NCIC DATA BASE QUERIES, UPDATE
NCIC DATA BASE RESPONSES
STATE DATA BASE AND SWITCHER
DATA BASE QUERIES, UPDATES
DATA BASE RESPONSES
NCIC DATA BASE WASH. D.C.

Figure 3-1. NCIC Traffic Flow

(3) All transmissions of responses to data base queries and updates between NCIC and the state switching center should be counted as communication messages.

(4) The final transmission of the response to the NCIC data base query or update from the state switching center to the user should be counted as a communication message.

Transactions should be counted as follows:

(1) The switching or automatic generation of a message by the state data base computer into NCIC should be counted as a transaction.

(2) The switching of the NCIC response by the state data base computer to the appropriate user terminal should be counted as a transaction.

If the states' traffic statistics do not follow these conventions, adjustments should be made.

Communication traffic traveling from the state system to the NLETS system is measured in the same way as NCIC traffic with the following exceptions. First, all communication messages sent from state system users to other states via NLETS must be sent directly, i.e., there is no automatic generation of messages to other states. Second, other states can originate data base queries into the state data base.

Communication messages to and from NLETS should be counted as follows (see Figure 3-2):

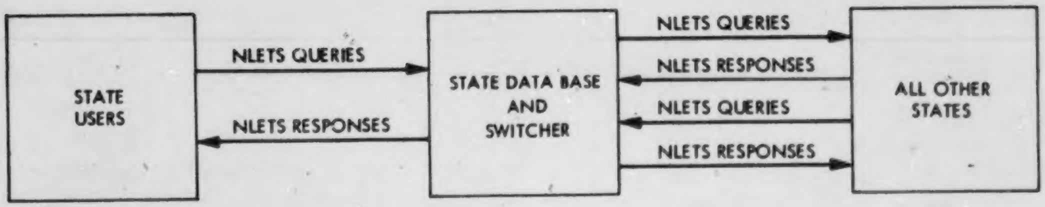

STATE USERS
NLETS QUERIES
NLETS RESPONSES
STATE DATA BASE AND SWITCHER
NLETS QUERIES
NLETS RESPONSES
NLETS QUERIES
NLETS RESPONSES
ALL OTHER STATES

Figure 3-2. NLETS Traffic Flow

(1) All initial NLETS queries from state users to the state data base should be counted.

(2) All queries from the state data base to other states via NLETS should be counted.

(3) All responses from other states to the state data base via NLETS should be counted.

(4) All transmissions of the NLETS response from the state data base should be counted.

(5) All NLETS queries from other states to the state data base should be counted.

(6) All NLETS responses from the state data base to other states should be counted.

Rules for counting NLETS transactions are:

(1) The switching of an NLETS query by the state data base to other states should be counted.

(2) The switching of NLETS responses by the state data base to state users should be counted.

(3) The file search and response preparation done by the state data base in responding to an NLETS inquiry from another state should be counted.

Again, care must be taken in examining states' procedures for measuring NLETS traffic levels. If the measuring procedures do not follow the above rules, adjustments must be made.

Once the traffic statistics have been analyzed and a good measure of the number of communication messages has been obtained, it is necessary to convert traffic from units of messages per day to characters per day. Our procedure for this conversion is presented in the next section.

3.3.3 Message Length

For the purpose of designing a network of communication lines, communication planners must know in addition to the number of messages, the length of the messages so they can determine the number of characters that are to be flowing on communication lines.

Determination of average message length begins by identifying message types and message functions. Message types are the state data base file types, administrative messages, NCIC messages, NLETS data base messages and NLETS administrative messages. Message functions apply only to data base message types and can be grouped into two categories: data base queries and data base modifications.

Lengths of data base message types by message function were determined by examining specified formats in users operating manuals. Response formats were also shown in these manuals. However, there are two possible responses to the query message function. The first is a short response indicating that no record matching the input identifiers could be found. The second, a positive response, is a longer message transmitting the entire record requested. Therefore, it is necessary to know the positive response rate in order to calculate average message length of responses to inquiries.

Average administrative message lengths were estimated by examining example administrative message formats, by discussions with state personnel and by examining available statistics kept by NLETS on administrative message lengths. Since the format of an administrative message is left to the discretion of the user, message length could not be determined by studying format specifications. However, good agreement was obtained from the three sources listed above, increasing confidence in the administrative message length estimates.

Message lengths for NCIC and NLETS messages were obtained from a previous JPL report (National Criminal Justice Telecommunications Requirements). These numbers were slightly modified to reflect changes since the JPL report was released.

A simple example of the method for calculating overall average message length will be presented and then the methodology will be generalized to cover our more complex case.

Suppose there are only two message types and the average length of message type 1 is L_1 and the average length of message type 2 is L_2. Also suppose F_1 is the fraction of total messages that are type 1 and F_2 is the fraction of total messages that are type 2. Overall average message length can be calculated as follows:

$$\text{Overall Average Message Length} = F_1 \times L_1 + F_2 \times L_2$$

To continue the example by assigning values. let:

L_1 = 100 characters/message

L_2 = 150 characters/message

$F_1 = 0.30$

$F_2 = 0.70$

Then:

$$\text{Overall Average Message Length} = 0.3 \times 100 + 0.7 \times 150 = 135 \text{ char/msg}$$

In our case we have more than two message types and there are also different message functions within message types. We do however know the average message length and the fraction of total traffic of each message function within each message type. We can thus apply the methodology presented above by taking the summation of the products of average message lengths and fraction of total traffic over all message functions and message types. An example is shown below where there are m message types and n message functions within each message type. The fraction of total messages and the average message length is shown for each message function and the calculation of overall average message length is shown at the bottom.

Overall average message lengths in the model states were calculated using the above methodology.

3.3.4 Peak/Average Ratios

In determining needed communication capacity to satisfy performance requirements, we would like to use a measure of demand that reflects the load on the system during the busiest hours. Proper network design requires that service objectives be met during the busiest times as well as the average situation. All previous traffic statistics have given message volumes averaged over a day. To derive the desired traffic measurement we establish the ratio of traffic volume during the busiest hour and average traffic volume and designate it the peak to average ratio. Average traffic volumes are then multiplied bv this ratio to give peak traffic volumes.

Peak to average ratios can be associated with different components of the communication system. At the first level we examine peak/average ratio of the number of messages sent from a user agency. The second level involves demand for communication circuits. In some instances, where there is only one user agency on a circuit, this cor-

	Fraction of Total Messages	Average Message Length
Message Type 1		
Msg Func 1	F_{11}	L_{11}
Msg Func 2	F_{12}	L_{12}
.	.	.
.	.	.
.	.	.
Msg Func n	F_{1n}	L_{1n}
Message Type 2		
Msg Func 1	F_{21}	L_{21}
Msg Func 2	F_{22}	L_{22}
.	.	.
.	.	.
.	.	.
Msg Func n	F_{2n}	L_{2n}
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
.	.	.
Message Type m		
Msg Func 1	F_{m1}	L_{m1}
Msg Func 2	F_{m2}	L_{m2}
.	.	.
.	.	.
.	.	.
Msg Func n	F_{mn}	L_{mn}
	$\overline{1}$	

$$\text{Overall Average Message Length} = \sum_{\begin{pmatrix}\text{Message}\\\text{Type}\\i\end{pmatrix}=1}^{m} \; \sum_{\begin{pmatrix}\text{Message}\\\text{Func}\\j\end{pmatrix}=1}^{n} (F_{ij} \times L_{ij})$$

responds to the first level. However, for those circuits serving more than one user agency, a separate peak/average ratio can be computed. This circuit ratio is dependent on communication line configuration and therefore changes as new configurations are proposed. To avert this complication we have assumed one constant peak-to-average ratio for the entire communication system. This one value is taken to be the peak-to-average ratio of traffic to the computer. We justify using this as the peak/average ratio for user agencies and communication circuits for the following reasons:

(1) Historically, the utilization level of the computer has been significantly higher than the utilization levels of communication circuits. Therefore it is more important to establish demands for computer service than for communication lines and user agency terminals.

(2) It is likely that the peak/average ratio for communication circuits and for the computer are not greatly different.

(3) There is a possibility that particular user agencies will have peak/average ratios somewhat higher than the computer's ratio. However, it is unlikely that this higher than predicted number of messages would have any impact on network system design since communication circuit utilization is low.

To determine this ratio we examine in detail one month of total system traffic data. The number of transactions occurring each hour in the month is determined. We search for the busiest hour and determine the ratio of transaction volume during this busiest hour to the average hourly transaction volume during the month. This ratio becomes the peak/average traffic ratio.

Predictions of average traffic levels are then multiplied by the peak-to-average ratio to describe traffic levels during the busiest hour.

3.3.5 Output of Analysis of Traffic Statistics

The outputs of the traffic analysis task are:

(1) Historical traffic statistics: 1971 - 1976

  (a) Number of average total monthly communication messages

  (b) Number of average total monthly transactions

  (c) Number of average monthly communication messages by system user

    (d) Number of average monthly communication messages by message type.

  (2) Current traffic statistics

    (a) Average message length by message type

    (b) Total average message length

    (c) Peak/average ratio.

This information on past and current traffic statistics serves as input into the traffic growth and distribution modeling tasks to be discussed in the next two sections.

3.4 TRAFFIC GROWTH MODELING

3.4.1 Introduction

Before we present our forecasting techniques a note of caution is in order; forecasting is a hazardous occupation. As Martino has said (Technological Forecasting for Decision Making) "The forecaster is never absolutely certain that he has prepared the most useful possible forecast with the data he had available and the resources he employed." Martino continues to describe what forecasting does and does not do. "A forecast does not tell us anything about the future. Instead, it tells only of the implications of available information about the past. These implications are connected with the future through a logical framework. Hence, the utility of a forecast for decision making purposes depends on the validity of the logical framework it uses, and the extent to which it extracts all the implications which are contained in the body of available information." We have attempted to identify the body of available information and develop a logical framework allowing us to use the information to predict future growth of criminal justice telecommunications traffic.

Our basic forecasting framework postulates that past traffic growth is caused by two factors. The first is an increased demand by the users and the second is communication system improvements. We assume that growth in traffic due to the first factor will continue in the future as it has in the past. However, growth in traffic due to communication system improvements will depend on the rate of future system improvements. Our estimates of these two components of traffic growth are combined to form the prediction of total future communication traffic levels into existing data types.

3.4.2 Input Data

Data describing past operations of the state criminal justice telecommunications system included past traffic statistics, past network configurations and past operational procedures. Recall that traffic statistics obtained from Ohio were used to determine the total number of communication messages each month and total transactions each month during the years 1971 - 1976. In addition, these aggregate monthly traffic figures were broken out by message type and wherever possible by user agency.

Data on past network configurations included location, content, and size of data files; communication line configurations and capacities; and lists of all user agencies and their means of access to the state telecommunication system. An operational procedure affecting traffic was the policy regarding the automatic generation of messages from the state computer to the National Crime Information Center maintained in Washington, D.C.

3.4.3 Data Analysis

Historic traffic statistics were used to establish the past growth pattern of communications traffic. Growth in traffic in Ohio, shown in Figure 3-3, was characterized by periods of fairly stable growth rates; however, there were erratic periods where large increases or decreases in traffic occurred. The decreases which occurred were explained by the obsolescence of vehicle registration files each spring. The sudden increases in traffic were caused by improvements to the communication system. The following improvements were identified:

(1) Addition of new users

(2) Addition of new data files

(3) The substitution of high-speed communication lines for low-speed lines and new terminal equipment

(4) Changes in operating procedures that provide the user with additional information per query

(5) Mobile Digital Terminals (MDTs).

Since these increases in traffic could be tied to specific communication system improvements and were short term in nature, it would be inappropriate to project such increases into the future. It thus becomes necessary to factor out the impacts on traffic of these improvements to the communication system. The remaining growth component is categorized as baseline growth and we see it as being principally caused by:

(1) Increased utilization of existing services

(2) Population and personnel increases

(3) Training.

Baseline growth, shown in Figure 3-4, is assumed to continue in the future as it has in the past.

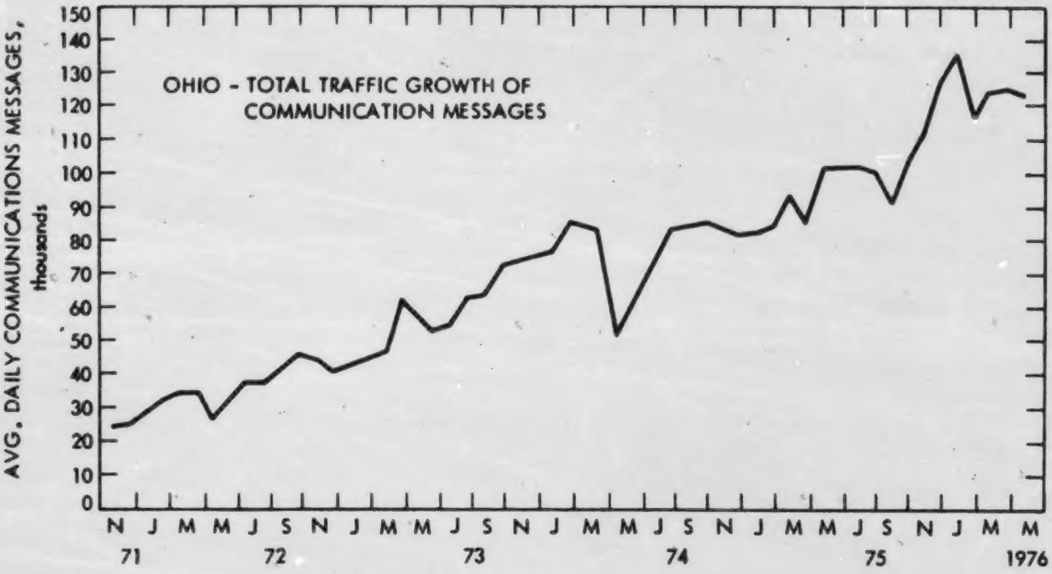


Figure 3-3. Ohio Past Communication Traffic Growth

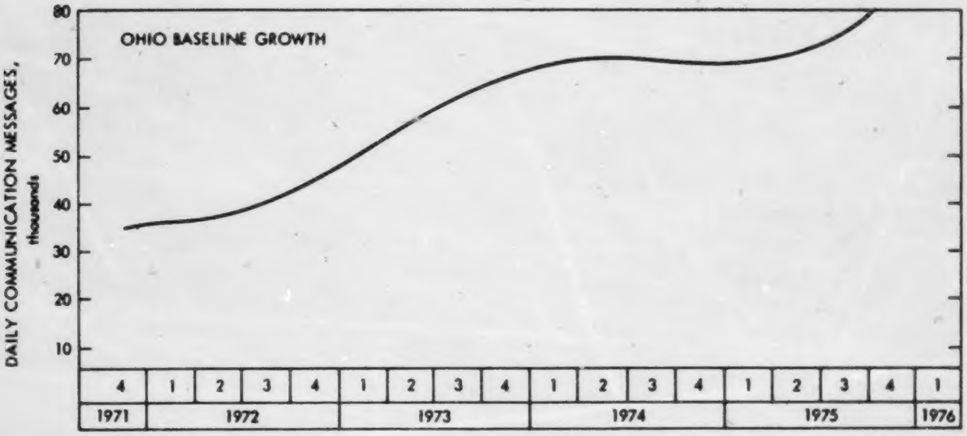


Figure 3-4. Ohio Baseline Traffic Growth

3.4.3.1 Past System Improvements. To obtain baseline growth statistics, we had to establish a procedure for quantifying the impacts on traffic of communication system improvements. Our procedure assumed that the traffic impacts of system improvements were independent of one another. We recognized that in the real world this is not the case, but were confident that the errors caused by non-independence would be small. As an example assume that two system improvements occurred simultaneously and were the conversion of low-speed lines to high-speed lines and the addition of a new data base. To determine the increase in traffic from a particular user caused by the high-speed line upgrade we look at the user's traffic just before and just after the increase. The increase is taken to be caused by the line upgrade. However, a portion of the increase is due to traffic into the new data file. However, during all periods the portion caused by the secondary effect was sufficiently small that it could be ignored. So errors resulting from our assumption of independence are small. Procedures for determining the impacts of each system improvement are now discussed.

Ohio has added new user agencies to its communication system over the last few years, and we collected a list of all new agencies added within each three month period from 1971 - present. The increase in traffic caused by the addition of a new terminal was obtained by measuring traffic levels from the terminal in the three-month period after it had been added. The average of traffic over this three-month period was considered to be the traffic increase. In Ohio, for the period September 1971 - April 1976 approximately 14,600 of the new messages per day could be attributed to the addition of new user agencies.

When a new data file is added, there is generally a period of two or three months of rapid growth of traffic into the files followed by a stabilization in traffic volume. It is this sudden increase in traffic that we consider the impact of the implementation of a new data base. An example of traffic volumes into a new data files is shown in Figure 3-5. Traffic increases into the new Wants-Warrants file occur rapidly during the first month of operation and stabilize into a normal growth pattern after this first month.

Ohio originally designed its state criminal justice telecommunication system with low-speed teletype lines but has since upgraded a portion of these lines to high-speed 1200 or 2400 baud lines. We define low-speed lines to be 300 baud or slower. Terminals serving low-speed lines are either older teletype terminals or hard copy printing terminals. High-speed lines are 1200 baud or faster and are served by CRT terminals. Ohio does not use lines of between 150 and 1200 baud.

The impact of past conversions to high-speed lines is measured by taking the difference in traffic the month before the upgrade and the month after the upgrade for each affected agency. These increases range from 12% to 200%. In Ohio a 50% average increase was observed after conversion to high-speed lines.

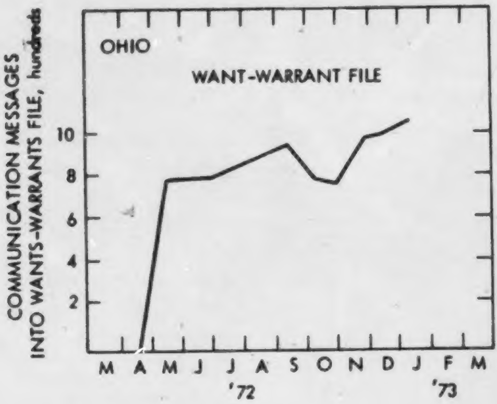


Figure 3-5. Example of New File Traffic Growth

A change in operating procedures that affected traffic levels occurred in Ohio. During the summer of 1973 the Ohio state computer began passing all queries into the state vehicle registration file on to the national stolen vehicle files. This procedural change was reflected in the traffic statistics as the number of messages per day to and from NCIC increased from 6,500 to 18,000. This procedural change is regarded as a system improvement because it provided more information to the user with no extra work required on his part.

The final past system improvement was the implementation of mobile digital terminals. These are computer terminals that are placed in patrol cars and allow faster access to information contained in the state data bases. Between March 1975 and April 1976, one hundred Cleveland patrol cars were equipped with mobile digital terminals. The increase in traffic due to these in-car terminals was 3,600 messages per day.

The effects of all the above system improvements in Ohio are summarized in Figure 3-6. Slightly more than half the growth could be attributed to baseline growth, and the addition of new users and the policy of forwarding messages into the national data file were the major system improvements.

3.4.3.2 Past Baseline Growth. Calculation of baseline growth began by using as input the total monthly historic communication message levels. These statistics were then averaged over three-month periods giving average message volumes for the four quarters of each calendar year. We then determined the component of each of these quarterly message volumes that could be attributed to the communication system improvements discussed above. Traffic caused by system improvements was subtracted from total traffic. The remaining traffic for each quarter was then plotted (see Figure 3-4) and served as a measure of baseline growth.

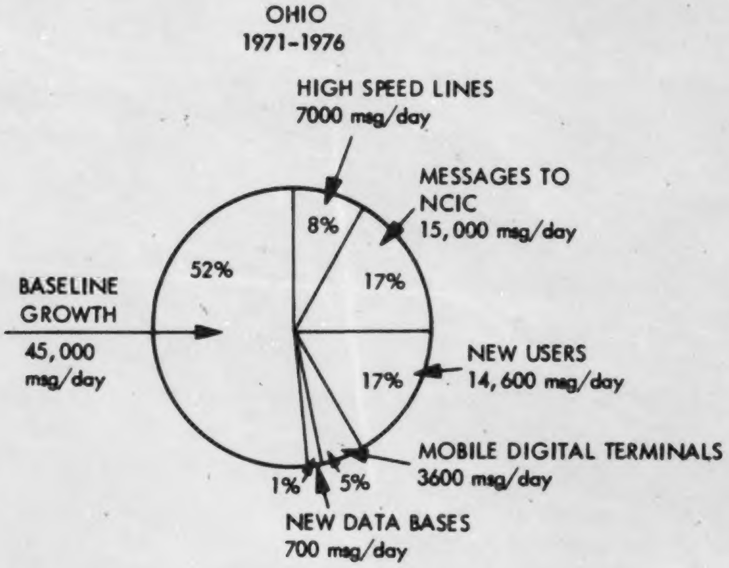


Figure 3-6. Distribution of Traffic Growth Sources

3.4.4 Traffic Projections

The previous section dealt with establishing past growth patterns and our attempt to relate portions of the past growth to communication system improvements. We will now use the knowledge gained about the past to predict future traffic levels.

3.4.4.1 Future Baseline Growth. Recall our basic assumption that baseline growth will continue into the future as it has in the past. Past baseline growth curves exhibited the following characteristics:

(1) A long-term increase in traffic

(2) Seasonal effects due primarily to procedures or customs

(3) Periods of relatively slow growth.

Using these characteristics we construct the following baseline growth model. The long-term increase in traffic will continue into the future. Seasonal effects may continue into the future but will have no impact on system design because although these effects have been to cause exceptionally low traffic levels during some months, the system must be designed to handle the loads during peak traffic months. We will thus not include seasonal effects in our future traffic model.

We explain periods of slow baseline growth as being caused by one of two factors. First, growth may be slow because the communication system is near saturation. Users experience deterioration in the level of service with the primary effect being an increase in the waiting time for a reply to an inquiry. Second, growth may be slow immediately following an upgrade because of sub-standard system performance while the inevitable problems of a new system are corrected, and reduced agency utilization while users familiarize themselves with new operating procedures.

In Ohio, major system upgrades occurred in October 1971 and March 1975. Examining baseline growth (see Figure 3-4) we note that the slow growth periods are the fourth quarter of 1971 through the second quarter of 1972 and the third quarter of 1974 through the third quarter of 1975. In the first case we observed slow growth through three quarters after an upgrade and in the second case we observe slow growth three quarters before an upgrade and two quarters after the upgrade. Unfortunately there are no response time statistics available in Ohio during periods of slow growth prior to the March 1975 upgrade. Thus we cannot document our contention that slow growth was caused by increased response times. We do know that the upgrade involved the replacement of an IBM computer with a UNIVAC system. According to Ohio system planners it was a difficult transition with considerable deterioration in service as the problems of a new system were corrected.

In Ohio, the state criminal justice telecommunications system is centralized with all files maintained and all switching services performed by one computer. The demands for service are such that the utilization of all other system components including communication lines and terminals are low. Response time deterioration caused by excessive demands for service thus are governed by response time performance of the central computer. Figure 3-7 shows a general case of this response time performance. Notice that response times stay relatively constant as transaction volumes build until a critical point is reached (about the 80% utilization point). Response times then degrade rapidly. The response time profile just described is consistent with baseline traffic growth observed in Ohio.

We will now use these past traffic baseline growth characteristics to predict future traffic volumes.

We have developed a growth projection model that predicts average daily traffic volume for each of the next 20 six-month periods. The model assumes that growth will be caused by three factors. They are: baseline growth, improved communication technology, and new users and data bases.

We assume baseline growth will continue into the future as it has in the past. In Ohio past baseline growth displayed an S-shaped curve with growth being slow before and after system upgrades and linear between these periods. Since baseline traffic growth appears to be dependent on available system capacity it becomes necessary for us to make assumptions regarding actions to be taken by the state when system saturation is reached. Possible actions are:

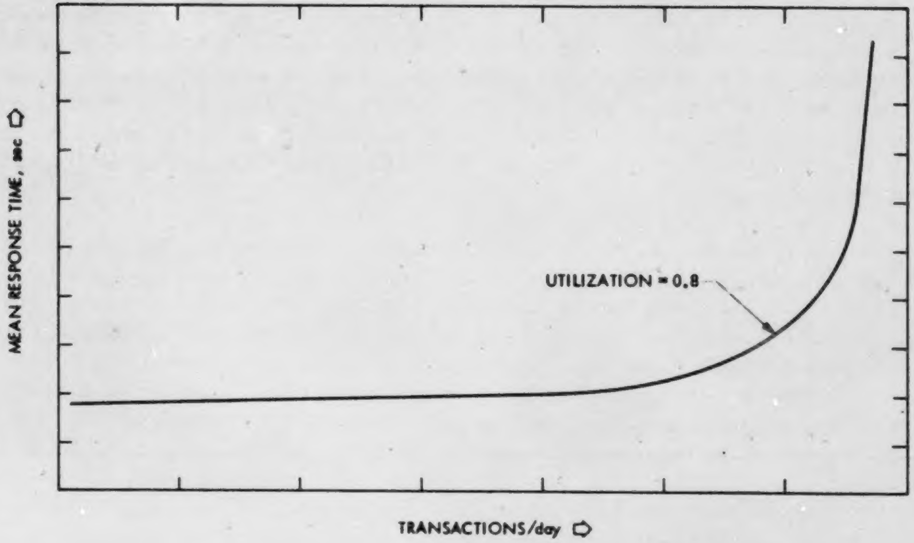


Figure 3-7. Typical Communication System Response Time as Function of Traffic Volume

(1) To increase capacity before saturation is reached to avoid inconvenience to users and allow unconstrained growth

(2) To wait for the first signs of saturation and then increase capacity

(3) To delay for a substantial period any upgrade even after saturation is reached

(4) To fix a limit to growth and not upgrade at all.

In talking with planners in Ohio, the second action seemed the most likely. Ohio planners believed that it was not possible to increase capacity before system capacity was reached but did indicate that funding necessary for increasing capacity could be obtained quickly when deterioration in response times was noticed. Thus the shape of the future baseline growth curve was assumed to be basically linear with a slowing of traffic before and after system upgrades.

Our assumption concerning possible actions regarding system upgrades is a critical one. If the state decides to delay upgrades for a substantial period or to fix a limit to growth, then our traffic predictions will be substantially high. However, if a state decides to increase capacity before saturation is reached, errors in our prediction will not be as large because decreased traffic growth periods have been assumed to be short term.

To project future baseline growth we fit past baseline growth statistics with regression lines and minimize the least square errors. A slow growth line and a fast growth line are developed.

Then, using our knowledge of present system capacity and assumptions on delay before capacity increase and magnitude of capacity increase, we can project these baseline traffic growth lines forward. Figure 3-8 shows our baseline growth projections.

3.4.4.2 Future System Improvements. In addition to increases in traffic volumes caused by baseline growth, there will be increases caused by communication system improvements. The future implementations of the following communication system improvements and their impacts on traffic were considered.

(1) The substitution of high-speed communication lines to low-speed lines and new terminal equipment

(2) The implementation of Mobile Digital Terminals (MDTs)

Information concerning implementation plans was obtained from state planning personnel and there is considerable uncertainty in their future scenarios. However, we did attempt to talk with as many people as possible to gain the most complete understanding of the state's plans.

Ohio has plans for converting all remaining low-speed communication lines to high-speed lines. We have estimated the effect of this conversion by assuming that traffic increases in the future will be similar to traffic increases resulting from past line upgrades. Recall that there was a 50% increase in traffic in Ohio when lines were converted from low- to high-speed.

This conversion process is assumed to begin in late 1977 and to be completed by early 1978. We have estimated an additional 18,000 msg/day resulting from low- to high-speed line conversion in Ohio.

In conversations with municipal police departments we learned that there is considerable interest in mobile digital terminals. Radio dispatchers currently serve as the link between officers in their patrol cars and the states' law enforcement data bases. Officers must gain the attention of the dispatcher and verbally relay the information necessary for a transaction into the data files. Responses must again be verbally transmitted between dispatcher and officer. Terminals are available that can be installed in patrol cars allowing the officer to enter and receive information directly from data bases. The officer utilizes a keyboard to enter information that is then transmitted digitally from patrol car to dispatcher station and then forwarded automatically into the data base. The response is again automatically forwarded from dispatcher station to patrol car and displayed on a read-out device in the patrol car. Mobile digital terminals thus relieve dispatchers

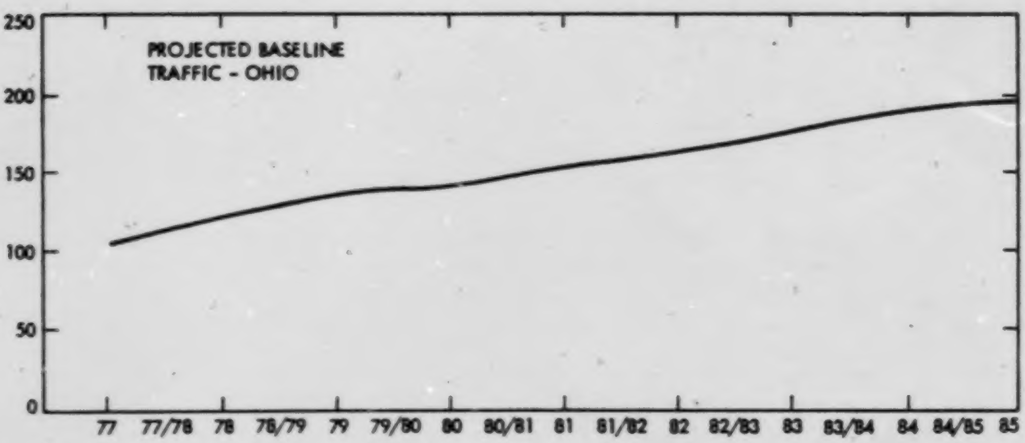


Figure 3-8. Projected Ohio Baseline Traffic Growth
(Average Messages/Day, thousands)

of a portion of their workload, ease communication channel congestion, and facilitate easier access to, and faster responses from, central data bases. It is thus expected that communication message volume will increase when mobile digital terminals are added to police vehicles.

In spite of the advantages mentioned above, the spread of mobile digital terminals has not occurred as rapidly as expected three or four years ago. The primary reason is cost. These in-car terminals cost between $3,000 and $5,000 per unit and municipal police departments find it hard to generate needed funds. In the past, significant funding for mobile digital terminals (there are currently approximately 1,000 operational units throughout the United States) came from the Law Enforcement Assistance Administration (LEAA) which funded these units as a part of an innovative project. It is unlikely that LEAA will continue to provide funds at the previous level for further mobile digital terminals. Thus municipal police departments must evaluate the performance of existing in-car terminals and determine whether mobile digital terminal benefits outweigh their costs.

Clearly the future of MDTs is an uncertain one. To aid us in forecasting future implementation we spoke with state planners, municipal police department planners and mobile digital terminal vendors. These sources agreed that the large municipal police departments would ultimately decide that MDTs were cost effective and equip their patrol cars with them. However, we assumed that only cities with populations of 500,000 or larger would purchase MDTs by 1985.

In Ohio this meant that Cleveland, Cincinnati and Columbus police departments would be adding mobile digital terminals. Cleveland is one of the cities that currently does equip a portion of its patrol fleet with in-car terminals. It was found in Cleveland that traffic between patrol cars and the state data base approximately doubled as a result of the addition of mobile digital terminals. We will use this rate of increase as a measure of the impact on traffic of the addition of in-car terminals. We assume implementation of MDTs will begin in 1980 and will be completed by 1984 and that 25,000 new msg/day will come as a result of mobile digital terminals.

It is apparent by the size of the increase predicted and the uncertainty in the future of MDTs that this is a possible area of substantial error in our traffic forecast. If in the future it is determined that growth in MDTs is slower or faster than we predicted, adjustments should be made to the traffic forecasts.

Table 3-1 summarizes the predicted increases in traffic caused by communication system improvements over the next 20 six-month periods. Designation 77 represents the middle six months of 1977, April-October, while 77/78 represents the last three months of 1977 and the first three months of 1978. The traffic increase numbers are given in units of messages per day and show the expected increase in traffic resulting from each system improvement that occurs in each six-month period.

These techniques used for projecting traffic growth forward can be applied in other states besides Ohio. The basic steps are:

Table 3-1. Future Traffic Increases due to Communication System Improvements (Units are Average Communication Messages per day.)

Time Period	High-Speed Lines	Mobile Digital Terminals
77	6,000	0
77/78	6,000	0
78	6,000	0
78/79	0	0
79	0	0
79/80	0	2,400
80	0	2,400
80/81	0	2,400
81	0	2,400
81/82	0	2,400
82	0	2,400
82/83	0	2,400
83	0	2,400
83/84	0	2,400
84	0	2,400
84/85	0	0
85	0	0
	18,000	24,000

(1) Analysis of past traffic statistics to determine the historical pattern of total system traffic growth

(2) Determination of past system improvements that would impact traffic growth

(3) Determination of the magnitude and the timing of past increases in traffic caused by system improvements

(4) Determination of the historical baseline growth curve by subtracting traffic increases due to system improvements from total traffic increases

(5) Determination of future baseline growth by projecting the baseline growth line or curve forward. Assumptions concerning future system capacity are factored in here.

(6) Determination of future system improvements and their impact on future traffic. Both the magnitude of the traffic increase and the implementation schedule must be predicted.

(7) The last step involves adding together future baseline traffic and traffic due to future system improvements to obtain the forecast for total future traffic into existing data files.

Recall that there is a third growth component which is growth due to the addition of new data types. Section 4 will discuss new data type traffic and in Section 5 we will delineate the method used in combining all three growth components to generate a total future traffic level forecast.

3.5 TRAFFIC DISTRIBUTION MODELING

3.5.1 Approach

Once total communication message volumes are known, we must determine the distribution of traffic among system users. Ideally, we would like to know the amount of traffic sent from every user to every other user. However, this is not possible simply because of the large number of system users. In Ohio where there are 364 system users, a matrix with 132,496 entries is required to describe traffic volumes sent from every terminal to every other terminal.

To avert this problem, we begin the traffic distribution task by identifying the major direction of traffic flow on the network. We can then eliminate all the user pairs for which there is very little traffic. Our next step is to determine the number of messages into and out of each user agency. This is accomplished by determining relationships between user agency characteristics and the amount of communications traffic sent and received by the agency. Once these relationships are developed, the final step involves using these relationships to predict future traffic distributions.

3.5.2 Input Data

Data required for the traffic distribution task included, for each current system user:

(1) Number of communication messages sent and received

(2) User characteristics

  (a) Population served

  (b) Number of personnel

  (c) Crime rate

  (d) Agency type

  (e) Type of communication line.

Communication message volumes were obtained from automatically generated statistics describing system performance in Ohio. The latest available three months of message volumes were averaged to reduce the effects of abnormalities in one month.

Information concerning user characteristics was generally available. Sources included user surveys, Uniform Crime Reports, the state survey, and state almanacs. We had the most difficulty obtaining data on the number of personnel. The complicating factor was that often an agency with a terminal into the state criminal justice telecommunication system will provide service to adjacent agencies that do not have their own terminals. Thus the user survey asked respondents to report the number of personnel requiring information available over the state criminal justice telecommunications system through the responding agency. Not all user agencies in Ohio responded to our survey but for those agencies not responding we were able to obtain data on the number of personnel employed from the Uniform Crime Reports. However, for these non-responding agencies, we were unsuccessful in determining which agencies with terminals were serving agencies without terminals. Thus for those agencies not responding to our survey, there may be errors in the number of personnel statistics.

Additional data were required concerning changes in user characteristics that would affect future traffic distributions. We assumed that population, number of personnel, and crime rate would be distributed in the future as they are now. However, we did account for future changes in communication line types. All low-speed lines were assumed to be converted to high-speed lines by 1979.

3.5.3 Data Analysis

3.5.3.1 General Traffic Flow. Traffic flows can be determined by examining the functions of the state criminal justice telecommunications system. They are:

(1) To provide access to information contained in state data files

(2) To allow for general distribution messages to be sent to law enforcement agencies in the state

(3) To allow for communication between two law enforcement agencies.

Approximately 90% of all messages in Ohio were data base related. Thus the major traffic flow involves messages from users to data bases and the subsequent response. In Ohio there is only one data base located in Columbus so all data base messages flow through it.

A general distribution message is issued when an agency needs to pass on information to many other agencies. Generally states establish sectors and allow users to send a message to all user agencies in the appropriate sector or sectors. A general distribution message sent to all system users and called an "all points bulletin" message generates a large volume of traffic so operators of the state telecommunication system review the message before it is distributed. In Ohio this means the APB message comes from a user agency into Columbus for review. If approved, the message is then sent out to all user agencies. Thus APB messages follow similar paths of flow as do data base related messages.

Administrative messages are free form messages sent between one user agency and another. Currently in Ohio these messages must go to Columbus for switching out to the appropriate agency.

The only way to completely describe traffic flows on the state network is to identify the amount of traffic going from every terminal to every other terminal. Recall, however, that this becomes impractical because of the large number of system users. Using our knowledge of traffic functions and major traffic flows, we can reduce the size of the traffic distribution matrix.

In describing traffic flow we must insure that our distribution matrix presents traffic statistics that can be used by the design team to test the major design parameters which are:

(1) The number of switchers

(2) The switcher locations

(3) The communication line sizes

(4) The communication line configuration.

Thus, we should not attempt to describe traffic between users and a particular switcher because our design team may examine options where that switcher does not exist. The location of data bases is not a design parameter so we can assume data base locations remain unchanged. Also, we will assume that there will be switching capacity located at the state capitol. Keeping these design parameters in mind we now discuss methods for describing data base messages, general distribution messages, and administrative messages.

Since data base location is not a design criterion the number and location of data bases is fixed. We can thus describe the number of messages between each user agency and each data base. Thus, currently in Ohio where there is one data base located in Columbus and 364 user agencies, a 364 X 1 matrix is required.

Messages into the NCIC and NLETS national systems have flow characteristics similar to messages into the central data base. Recall these messages originate from a user agency, flow into the state capitol, are switched to the national system, return from the national system to the state capitol, and finally are switched back to the original user agency. National traffic between users and the state capitol and between the state capitol and the national systems is treated as traffic between users and the central data base. Thus NCIC and NLETS are considered to be system users.

General distribution traffic and administrative traffic are both dependent on the location and the number of switchers. To describe accurately these message flows we need to know the exact communication system configuration. In addition, since these are messages between agencies we would require the complete origin - destination traffic matrix to describe traffic distribution. In order to avoid the need for this information we assume:

(1) General distribution and administrative messages flow as do data base queries to the state capitol

(2) Each user agency sends the equivalent number of administrative messages that it receives

(3) The ratio of general distribution messages sent and received is the same for all user agencies and is equal to the system-wide average.

These assumptions obviate the need to separate administrative and APB message types from data base message types. We need only report the amount of communication traffic between each system user and each data base. Administrative and general distribution messages are included in the count of messages between user agencies and the central data base. These assumptions, of course, lead to errors in the description of traffic flows.

Figure 3-9 shows a user agency that communicates with the state capitol via a regional switcher. An administrative or general distribution message would travel from the user to the regional switcher and then be sent out to the appropriate recipient(s). We assume, however, that the message is sent from the regional switcher to the state capitol and distributed from there. This leads to an overestimation of traffic on the communication line between the regional switcher and the state capitol. An example of the magnitude of this overestimation can be obtained by examining traffic on the existing Texas system (the other model state in the STACOM study). Actual traffic on the line between the Dallas and Austin switchers is 36,000 msg/day; while using the above assumption we would estimate traffic to be 40,000 msg/day, an 11% error. We feel this error is acceptable because:

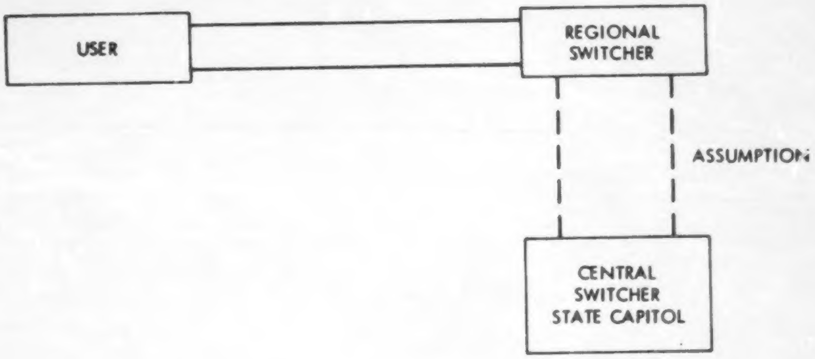


Figure 3-9. Communication System Configuration with Regional Switcher

(1) Overestimates of traffic will occur only on lines between regional switchers and the state capitol.

(2) There is a low probability that overestimates will affect communication system design.

(3) If there are design errors they will be in the direction of excess communication capacity.

We should mention that the above error could be alleviated if in reporting traffic from each agency, administrative and general distribution messages were reported separately. For any proposed system configuration, a closest switcher could be identified for each user agency and traffic could be described as flowing from the user agency to this closest switcher. An unattractive feature of this approach is that the design program would be required to describe traffic between each terminal and a variable number of locations which would be dependent on the number of switchers. It was our opinion that the errors associated with the assumptions were sufficiently small so that the added work required for a more accurate description was unnecessary.

Figure 3-10 shows existing major traffic flows in Ohio. NCIC and NLETS have been shown as separate user agencies because of their high traffic volume. The number of data base messages and administrative and general distribution messages between all user agencies and the central data base(s) are shown.

3.5.3.2 User Characteristics. In order to design the communication line configuration and the line sizes, we must describe traffic in more detail than is shown in Figure 3-10. The amount of traffic between each user agency and data base must be specified. Recall that these statistics are available for the present systems and that we attempt to establish relationships between user agency characteristics and these traffic statistics so that future traffic distributions can be estimated. User characteristics are agency type, communication line type, population served, number of personnel and crime rate.

Agency types are police, sheriff, state patrol and all others. The category "other" includes such agencies as university police departments, bureaus of criminal identification and federal agencies such as the Federal Bureau of Investigation, the Drug Enforcement Agency, the Internal Revenue Service, etc. Distributions of user agencies for Ohio are shown in Table 3-2.

Line types currently in use in Ohio are 150 bit/sec lines and 2400 bit/sec lines. Designating line types of 300 bit/sec or less as low-speed lines and line types of 1200 bit/sec or greater as high-speed lines, Table 3-3 shows the current line type distribution for Ohio. Ohio plans to replace all low-speed lines with high-speed lines.

Table 3-4 shows statistics describing the three remaining agency characteristics.

Table 3-2. Distribution of Ohio Users by Agency Type

Agency Type	Number of Users
Police Terminals	214
Sheriff Terminals	68
State Patrol Terminals	60
Other Terminals	22
Total	364

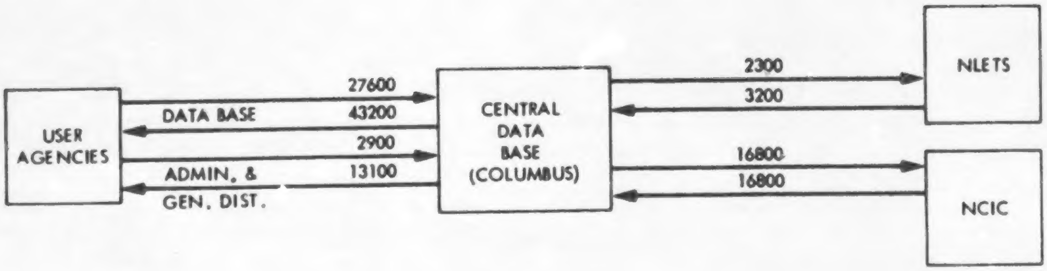

USER AGENCIES
27600
DATA BASE
43200
2900
ADMIN. & GEN. DIST.
13100
CENTRAL DATA BASE (COLUMBUS)
2300
3200
NLETS
16800
16800
NCIC

Figure 3-10. Existing Ohio Traffic Flow, Average Messages per Day

Table 3-3. Distribution of Ohio Users by Line Speed

Line Type	Number of Lines
Low-Speed	268
High-Speed	96
Total	364

There is considerable variation in the characteristics of the agencies served by these communication systems, especially in population served and number of personnel as these characteristics have standard deviations considerably larger than their mean. To further investigate variations in user characteristics, frequency tables were constructed showing the number of agencies falling within population and personnel categories. (See Tables 3-5 and 3-6).

A large percentage of users are small agencies with 45% of all Ohio terminals being located in agencies serving 20,000 or fewer people.

User characteristics clearly demonstrate the tremendous diversity existing between agencies served by the state telecommunication system. The methodology used in distributing traffic to these diverse agencies is covered in the next section.

Table 3-4. Ohio User Statistics: Population, Number of Personnel, Crime Rate

Agency Characteristic	Number of Agencies Reporting	Average Value	Standard Deviation
Population	346	55,362	120,520
Personnel	292	54	174
Crime Rate	324	3,560	2,240

Table 3-5. Population Distribution of Ohio User Agencies

Population Category	Frequency	% of Total
Less than 5,000	34	10
5,000 - 10,000	39	11
10,000 - 20,000	82	24
20,000 - 30,000	52	15
30,000 - 50,000	61	18
50,000 -100,000	43	12
100,000 - 200,000	17	5
200,000 - 500,000	10	3
500,000+	8	2
Total	346	100

Table 3-6. Number of Personnel Distribution of Ohio User Agencies

Personnel Categories	Frequency	% of Total
Less than 10	16	6
10 - 20	79	27
20 - 30	94	32
30 - 40	45	16
40 - 50	18	6
50 - 100	23	8
100 - 200	7	2
200 - 500	6	2
500+	4	1
Total	292	100

3.5.4 Traffic Distribution

3.5.4.1 Regression Techniques. Regression analysis is a technique that identifies potential functional relationships between independent and dependent variables. In our case we attempt to develop a relationship between the dependent variable of the number of communication messages and independent variables consisting of different forms of the parameters:

Population - POP

Personnel - PERS

Agency Type - AT

Communication Line Type - LT

Crime Rate - CR

We considered the following forms of the above parameters in attempting to explain the number of communication messages between each user and the data bases.

POP	$(POP)^2$	$(POP)^{1/2}$	$POP \cdot PERS$	$PERS \cdot AT$	$AT \cdot LT$	$LT \cdot CR$
PERS	$(PERS)^2$	$(PERS)^{1/2}$	$POP \cdot AT$	$PERS \cdot LT$	$AT \cdot CR$	
AT	$(AT)^2$	$(AT)^{1/2}$	$POP \cdot LT$	$PERS \cdot CR$		
LT	$(LT)^2$	$(LT)^{1/2}$	$POP \cdot CR$			
CR	$(CR)^2$	$(CR)^{1/2}$				

The variable selection procedure of stepwise regression was applied to these independent variables. Stepwise regression selects, from our total set of independent variables, those that are most highly correlated with the number of communication messages. It then utilizes the standard least squares technique to develop a functional relationship between communication message volumes and the chosen independent variables. The usual procedures were followed in determining the best coefficients for the model relations. (See Draper and Smith.)

3.5.4.2 Results. Like user characteristics, communication traffic levels vary greatly between system users. This increases the difficulty of the modeling task because even though we may be able to explain a substantial percentage of the variance, the standard error of our estimate may be high with respect to the mean.

In order to alleviate this problem, we have chosen to divide the user agencies into more homogenous groups in terms of information needs. In Ohio the following groups were formed:

(1) Police Departments (PDs) and Sheriff Offices (SOs) serving fewer than 20,000 people

(2) Police Departments and Sheriff Offices serving between 20,000 and 100,000 people

(3) Police Departments and Sheriff Offices serving more than 100,000 people

(4) All offices of the Department of Public Safety

(5) All other.

Police departments and sheriff offices were combined because they perform similar law enforcement functions and thus have similar information needs. State patrols on the other hand concentrate their law enforcement activities on traffic enforcement only. Other terminal groupings were tried such as combining terminals by agency and line type and by line type only. However, regression models developed for these groupings had larger standard errors and explained a smaller percentage of the variance than our final classification procedures.

Values used for line type and agency type were:

Line or Agency Type	Independent Variable Values
150 bits/sec	1
2400 bits/sec	2
Police Depts	1
Sheriff Office	2

Crime rate is a measure of the incidence per 100,000 population of the seven major index crimes (murder and nonnegligent manslaughter, forcible rape, robbery, aggravated assault, burglary, larceny, and auto theft).

Personnel is a measure of the number of employees whose information needs are being served by the computer terminals. Population is the size of populace served by the agency.

Table 3-7 shows the expressions which best describe the relationship between user characteristics and communication message volumes. These are complex expressions that in many cases contain different forms of the same variable. In some groups there appear to be terms that would intuitively be erroneous. For example, examining Ohio's first P.D. and S.O. group, $-43.7 + 50.7\ (\mathrm{PERS})^{1/2} - 0.000116\ (\mathrm{POP})(\mathrm{PERS})$, the last term affixes a negative coefficient to the product of population and personnel. This appears to be saying that agencies serving large populations and more personnel transmit fewer communication messages. However, the second term

Table 3-7. Regression Results - Ohio Communications Message Volumes (Messages per Day)

P.D. and S.O. < 20,000 People

$$-43.7 + 50.7\ (\text{PERS})^{1/2} - 0.000116\ (\text{POP})(\text{PERS})$$

P.D. and S.O. 20,000 - 100,000 People

$$-356 + 541\ (\text{LT})^{2} + 0.0000176\ (\text{POP})(\text{PERS})$$

P.D. and S.O. > 100,000 People

$$693 - 5.47\ (\text{PERS}) + 0.00223\ (\text{PERS})^{2} + 2.45\ (\text{PERS})(\text{LT})$$

Ohio State Patrol (O.S.P.)

$$400 + 13.2\ (\text{PERS}) - 8.73\ (\text{CR}) + 276\ (\text{LOG}\ (\text{POP}) - 3)$$

in the expression has a large positive coefficient attached to the variable personnel. In addition, there is a positive correlation between population and personnel so in general larger populations generally mean more personnel. Thus as population and personnel increase, the third term does become more negative but the second term becomes more positive. The net result is that the total expression becomes larger.

Personnel number is an important variable in determining the number of communication messages as it appears in all four expressions. As the number of personnel increases, the number of communication messages increases. The rate of increase of communication messages as personnel increases slows down for smaller agencies, and in general, stays constant for other groups.

Population appears in three of the four expressions. Since population and personnel are positively correlated, and since personnel is more highly correlated with communication message volume, population may be excluded from the regression equations. In those expressions containing population, the coefficient is sufficiently small such that the magnitude of the term containing population is small compared to the magnitude of the total expression.

Line type is important in determining communication traffic volume. The only places where it does not appear are those groups in which all agencies have the same line types. In all groups where a fraction of the agencies have low-speed lines and a fraction have high-speed lines, the high-speed line agencies display significantly higher message volumes.

Agency type does not enter into any of the expressions and crime rate appears in only one and is not highly correlated with communication traffic levels.

These expressions yield information useful to all states in determining traffic distributions. Conclusions are:

(1) Personnel and line type are important in determining traffic levels.

(2) Crime rate does not affect traffic levels.

(3) Personnel and population to a large extent measure the same thing, i.e., the size of the agency. Since personnel is entered in the above expressions, there is no need for population to play a significant role.

(4) Police departments and sheriff offices should be treated separately from state patrol offices.

(5) Sheriff offices and police departments may or may not have different traffic levels.

The expressions developed cannot be applied per se to any other states. However, the data collection and analysis procedures leading to the development of similar expressions is the same for all states. The steps of the procedure are:

(1) Determine general traffic flow. If a large percentage of messages are data base messages, describe message flow between each system user and data bases.

(2) Compile a user agency data base. Information on number of personnel, size of population served, size of communication line, agency type and any other parameter that may impact traffic volume should be collected for each user agency.

(3) Determine the number of messages sent and received from each terminal over a recent three month period.

(4) Develop relationships between traffic volume and user characteristics. Develop one relationship for each of the following groups.

  (a) Police Departments and Sheriff Offices serving less than 20,000 people

  (b) Police Departments and Sheriff Offices serving between 20,000 and 100,000 people

  (c) Police Departments and Sheriff Offices serving more than 100,000 people

  (d) State patrol.

(5) Use these relationships to predict future traffic distributions.

3.5.4.3 Accuracy of Results. The expressions developed in the previous section attempt to describe the number of communication messages originating from each user agency as a function of user agency characteristics. After the expressions are developed, we must assess their accuracy. Table 3-8 presents statistics describing the effectiveness of the regression equations.

Standard error is a measure of the differences in the actual communication traffic levels, and the levels calculated using the regression expressions. If:

y_i = Actual values of the dependent variable

$\hat{y}_i$ = Predicted values of the dependent variable

n = Number of observations

Table 3-8. Accuracy of Regression

Ohio	Standard Error	R^2	Mean Traffic	F-Ratio	SE/Mean
P.D. and S.O. < 20,000	58	0.25	154	19	0.38
P.D. and S.O. 20,000 - 100,000	86	0.60	262	72	0.33
P.D. and S.O. > 100,000	355	0.99	1,651	301	0.22
Ohio State Patrol	229	0.68	733	15	0.31

Then the standard error is:

$$\left\{ \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \right\}^{1/2}$$

If the standard error (SE) is small, we can be assured that our regression equations yield communication traffic volume close to the actual values. In our case, the standard error values are significant. However, the standard error should always be evaluated in relation to the mean value. If the standard error is small with respect to the mean, then our regression equations help us in assessing the amount of traffic originating from each user agency. The ratio SE/Mean is shown in Table 3-8. These ratios lead to fairly large error terms around predicted values, but the predictions are sufficiently accurate for our network design purposes.

The statistic R^2 is a measure of the amount of variation in the dependent variable explained by the regression equations. An R^2 value of 1.0 would mean a perfect fit between observed and calculated values. The closer R^2 is to 1.0, the larger the proportion of total variation about the mean is explained by the regression equations. In small police and sheriff agencies in Ohio the regression equations explain very little of the variation.

After the regression is performed, statisticians always consider the possibility that their entire approach was wrong. They ask themselves whether or not any of the independent variables should be included in the regression equation. This is equivalent to testing the hypothesis that all coefficients are zero. The F-ratio allows them to test this hypothesis. The larger the F-ratio, the more confident statisticians are in rejecting this zero coefficients hypothesis. In all cases, our F-ratios are sufficiently high such that we can reject the hypothesis with a high degree of confidence.

3.5.4.4 Future Traffic Distribution. Once these expressions for distributing traffic have been developed, they must be applied to the future traffic projections. The expressions are used to determine, at each future point in time, the percentage of total communication messages from and to each user agency. We have developed distributed traffic projections for years 1977, 1979, 1981, 1983 and 1985. A new user characteristic data base is used for each of these future time periods so that expected changes in line type, population and personnel can be reflected in future traffic levels.

Also, in the future there will be improvements to the communication system for a small number of user agencies that will cause their message volumes to increase. These increases will not be due to any factors contained in the regression expressions but will be caused by implementation of Mobil Digital Terminals. For these few user agencies, the percentage of total traffic will be increased to account for the above system improvements.

The last step in the traffic projection process is the conversion of traffic volume units from average messages per day to peak characters per minute. Messages are converted to characters as follows:

If

T_m = Average Traffic in Units of Messages/Day

L = Average Message Length in Characters

T_c = Average Traffic in Units of Characters/Day

then:

$$T_c = L \times T_m$$

This is then converted to peak characters per minute.

If:

P = Peak-to-Average Ratio (See Section 3.3.4)

T_p = Peak Trafic in Units of Characters/Minute

then:

$$T_p = T_c \times P \times \frac{1 \text{ day}}{1440 \text{ min}}$$

We are thus able to specify the traffic to and from each user terminal in units of peak characters per minute.

SECTION 4

TRAFFIC MODELING AND GROWTH PROJECTIONS: NEW DATA TYPES

4.1 DATA DESCRIPTIONS

New data types whose volumes are projected into the future in this section are summarized below. They are:

(1) Law enforcement use of state CCH/OBTS files

(2) Court use of CCH/OBTS files

(3) Corrections use of CCH/OBTS files

(4) Parole agency use of CCH/OBTS files if the agency is distinct and if the parole officers would not use law enforcement terminals in their areas

(5) A state judicial information system

(6) An offender-based state corrections information system

(7) A juvenile records system if the model state believes that it is feasible to include these data on a statewide criminal justice information system

(8) An automated fingerprint encoding, classification and transmission system

(9) State investigation bureau data conversion traffic.

The growth in traffic from these data types is shown in Figure 1-2. Descriptions of the files, users, hardware, facilities, and functions are provided in Section 2. This section outlines the methodology used to forecast traffic in these data types for the next decade. Other data types were considered, such as boat registrations and state parks department files, but were rejected because it is likely they would be used infrequently compared to those included in the study and would contribute an insignificant amount of traffic to the system. These minor data sources would therefore not alter the state network significantly, nor would they change the network performance.

4.2 SECURITY AND PRIVACY CONSIDERATIONS

To comply with Section 524(b) of the Omnibus Crime Control and Safe Streets Act, the National Criminal Justice Information and Statistics Service (NCJISS) of the Department of Justice's Law Enforcement Assistance Administration (LEAA) has published regulations in the Federal Register (40 FR 49789 of October 24, 1975, as amended by 41 FR 11714 of March 19, 1976) designed to assure the privacy of information on individuals contained in state criminal files and to assure the security of the files and means of access to them. The regulations seek to maintain the integrity of state criminal justice files by focusing on five major concerns:

(1) Assuring the completeness and accuracy of the information kept in the files

(2) Limiting the dissemination of information in criminal files to criminal justice and other lawful purposes

(3) Auditing the state agencies to assure compliance with the LEAA regulations

(4) Protecting the physical security of state criminal files from destruction and unauthorized access

(5) Allowing individuals whose records are contained in state criminal files to review and correct any erroneous information contained in them.

All states are required to submit plans for assuring the proper handling and operation of state criminal files. Ohio is in the process of complying with these regulations, and it is expected that all local criminal justice agencies in the state will likewise be required to comply, since the regulations apply to all state and local agencies that have received LEAA funds after July 1, 1973 for criminal records systems.

These LEAA regulations are expected to have very little effect on traffic through an Ohio criminal justice telecommunications system, since many of each state's criminal justice agencies already have their own individual security policies, and all users will be asked to comply with user agreements designed to assure compliance with LEAA requirements. For purposes of the traffic projections in this study, it has been assumed that the Ohio state plan for assuring the integrity of criminal records will be accepted by LEAA and that agencies responsible for the records, and user agencies, will comply with the approved state plans. It appears that none of the information transfers that have been identified as generating new data type traffic will be inhibited by security and privacy regulations. Traffic is therefore assumed to be unconstrained by security and privacy regulations. It is likely that other states will also comply with the federal guidelines and that their criminal justice communication system traffic will be similarly unconstrained. Such compliance will allow states to obtain maximum utility from the system.

4.3 DATA GATHERING TECHNIQUES AND RESULTS

4.3.1 Traffic Volume

Information on what future traffic levels in new data types might be was gathered primarily from state officials who have been administering criminal justice information systems in Ohio for the last several years, and from officials (often the same people) who are planning for the future of these systems. Responses from these data system administrators and planners were gathered in the form of written answers to formal written inquiries, by informal personal conversations, and by formal personal presentations to large groups of state officials who were invited to criticize the assumptions and analyses used in projecting future traffic in new data types.

In addition to talking with administrators and planners at the state level, data on the future of the state criminal justice information system were also obtained from speaking with local users in city police departments, and other local agencies such as county courts and sheriff offices. The following list summarizes the types of agencies visited in each model state:

State criminal justice information system operators

State criminal justice information system planners

Law enforcement users of the state and local criminal justice information systems such as city police departments and county sheriff offices

State judicial system planners and administrators of state judicial system statistics services

Operators and planners of local judicial information systems for general jurisdiction courts

Administrators and planners of state corrections information systems

Operators of state youth agency information systems

Administrators and planners of state parole information systems.

The following list summarizes the types of vehicles used to obtain estimates of future new data traffic volume from these several agencies:

(1) Formal written questionnaires (see Appendix A) were sent to the state criminal justice information system operators asking their judgment on what new data types they expected to see on their network in the next decade. These questions were part of the formal written questionnaire that asked for detailed traffic statistics on existing data types and for past historical trends in data volume. If the state operators of the criminal justice information system indicated there would likely be another type of data added, this statement was followed up by a phone call or visit to the agency which would provide the expected data in order to obtain better estimates of when the data might appear on a state system and what its volume would be over a period of time.

(2) Formal meetings were held with operators, administrators and planners of the criminal justice information systems in each state to present the STACOM team's assumptions and forecasts for the future of the traffic volume. These "advisory committee" meetings consisted of presentations by the team members concerning the team's assessment of what future traffic in new and existing data types would be, and how this would affect the design of the state information system over the next decade. After the formal presentations, participants from all agencies were invited to discuss the material presented and offer suggestions on how the traffic projections could be made more accurate. These discussions also usually led to further individual discussions with present or potential users to obtain more accurate projections of how each agency thought its traffic level would change over the years.

(3) Individual discussions were held, often several discussions, with all of the agencies listed above. Visits were made to the state offices of all agencies involved in criminal justice and to several representative local agencies that either use or administer automatic data processing facilities. A single visit was usually insufficient to obtain all the information required to gather realistic data traffic volume projections, so several telephone calls were generally made to clarify the estimated future traffic and to obtain user response to assumptions and projections that the STACOM team had made based on earlier formal discussions or written responses.

It should be emphasized that future traffic volume estimates were usually obtained from individuals within the criminal justice community who were advocates of the effectiveness of automatic data processing, or at least convinced that it was a benefit to their agency. Criticism of the existing systems was heard from several individuals, but it was usually accompanied by suggestions for improvements that are already planned or that are likely to be made. There was no opposition to the basic idea that automatic data processing use would become more extensive in criminal justice or that it was a significant benefit to the record keeping and rapid communication required of law enforcement, court and corrections institutions.

Discussions with state agencies and with users of the state criminal justice information system were held in the context of trying to determine what could happen to traffic volume on the system over the next decade, not what should happen or what will happen. It was therefore important to get the best judgment of state officials concerning present state policies and budgets and their ideas about what future policies and budgets might be. Whenever these projections left room for scenarios that would lead to low or high traffic volumes, or to the addition of a new data type or not adding it, it was usually decided to assume the higher traffic volume so that communication lines and computers would be adequate to handle the higher load. Except for CCH/OBTS estimates, a low or high estimate for traffic in a single data type made little difference in the statewide network design or in the size of the required computing facility since these data types are projected to account for a small fraction of the total traffic volume. Thus, large variations in the estimates of traffic for these new data types have very little effect on the design of the statewide system.

In the discussions with both operators of the state systems and with the individual user agencies, questions were always asked concerning the functions of both the agency itself and of the data which were being transmitted on the statewide system. From the answers to these questions, it was possible to estimate two of the factors which are used in the following sections to forecast future traffic volumes. By obtaining a qualitative estimate of the implementation schedule for a new data type, a "technology penetration factor" was estimated which is used to specify the fraction of the total statewide potential use of the specific data type. By discussing the functions of the agency and its information needs, it is possible to estimate the number of transactions the terminals assigned to the agency will have with the state information system per arrest or per inmate per day or per court case disposition or per whatever measure is used for the agency's activity level.

User discussions also brought out whether the data used by the agencies are needed in real time or whether a slower means of transmission is acceptable. For instance, in the case of judicial statistics, it is likely that these need not be transmitted to a state judicial statistics center in near real time, but it was decided that, since large information systems are available at both the courts and at the state data center, it would be wise to connect them and avoid the cost and manual processing of the statistics by including this type of data on the state system. On the other hand, in some cases it was decided not to include certain data types on the state system because of the high cost involved for only marginal convenience or benefit. An example of this is the decision to assume that only the four or five largest cities in the state would have fingerprint volumes high enough to justify the great cost of automatic fingerprint processing equipment. Cities with smaller arrest and fingerprint volumes would therefore have to rely on facsimile transmission or communication by mail.

In Ohio user and operator discussions were useful in trading off regional data bases versus a central state file and in estimating the effects this would have on the traffic over a statewide network. It was decided, for example, that court information systems that kept track of offender processing to the detail of court calendar control would best be handled on a local or regional level as it already is in several jurisdictions, and that only court statistics would be transmitted on the statewide networks.

The techniques of written survey, individual discussions with operators, planners and users of the criminal justice information system, and presentations to advisory groups of criminal justice information system experts from the model states can, of course, be used on any state and with any potential user agency in the state. Ohio cooperated fully with these methods of determining its information processing needs and we believe that the projections are therefore as realistic as it is possible to be when dealing with the uncertain future.

4.3.2 Traffic Distribution

The techniques used for obtaining estimates of future statewide traffic volume were also used to project the distribution of that total data volume between the users throughout the state. As discussions were held with both state officials and data system users, comments were solicited concerning how much data traffic would flow to each of the offices of an agency. In some cases simple mechanical estimates were made such as prorating the total traffic to the correctional agency between the several institutions according to the number of inmates in each facility. In other cases the uniform proration according to arrests or offender volume was tempered by past experience to arrive at estimates that suggested, for instance, that certain facilities such as reception centers for correctional agencies generated far more information than those with no offender processing function. Thus, at the same interviews and presentations, data were obtained which allowed projections of both total statewide criminal justice information system traffic volume and the distribution of that traffic throughout the state.

4.3.3 Results

Questionnaire responses, discussions with state officials, and presentations to the Ohio advisory committee suggested that the following types of new data should be included in the STACOM projections for the next decade:

Law enforcement use of a CCH/OBTS file

Court use of the CCH/OBTS file

Use of the CCH/OBTS file by state correctional institutions

Local or regional SJIS files connected to a state system for the purpose of transmitting court statistics

An OBSCIS system for the state correctional facilities

A network for transmitting automatically processed fingerprints from the state's largest cities to central state files

A traffic component associated with the conversion of present manual CCH/OBTS files to computerized files and with the maintenance of those automatic files.

During the time of the Ohio STACOM study, it was unclear whether Ohio intended to implement a statewide criminal history system that would include reports on both felonies and misdemeanors, and would include all the data elements of a computerized criminal history and those of an offender based transaction statistics system. There was a bill pending in the state legislature that would require all local jurisdictions to report both felonies and misdemeanors to state data bases, but some state officials anticipated strong opposition to this bill from local law enforcement agencies because many of the agencies had insufficient manpower to fingerprint and process all misdemeanants to the same level of formality as felons, which would be required if these reports were to be included in state files. Other state officials, however, felt that, independent of the concerns of the local police officials, the bill requiring reporting on all offenders would pass and a state criminal information system should account for this eventuality. It was also uncertain as to the number of data elements that would be included in the Ohio criminal history system - whether it would encompass a more limited set of CCH data elements, or whether a lengthier OBTS format would be used. In both cases - the question of whether both misdemeanants and felons would be included in the system, and that of how extensive the data files would be - the judgment of the state officials was used, tempered by the philosophy that this project did not want the STACOM system to be undersized, so if a lower or higher traffic estimate could be made, the higher volume was chosen. In Ohio, this meant that all offenses, both felonies and misdemeanors, were included in the traffic volume, and the size of the messages was that estimated by the officials who operate the present LEADS system in the state -- usually on the order of a 960-character page for entries. The basis of the law enforcement CCH/OBTS network was taken as the present LEADS network since state officials indicate that it is a relatively minor software and hardware modification to allow present LEADS users access to the existing CCH files. For this reason, future traffic projections for Ohio new data types show a very rapid growth in law enforcement CCH/OBTS traffic volume and suggest that the system will be fully utilized by about 1979.

The STACOM study also included court use of the proposed CCH/OBTS files in Ohio, based on discussions with local and state officials and on observation of similar local systems in two of the large metropolitan areas. In Cincinnati, the CLEAR system includes court tracking data elements, and in Toledo, the offender based system in Lucas County includes similar elements. In planning the STACOM network, therefore, these observations and discussions led the team to include court use of the state files, but only from the major metropolitan areas. It was assumed that if state files were made available for court access, one of the appellate judicial districts surrounding a large city that already had a local system operating would be the first to connect. In this case, Cincinnati and its CLEAR system were projected to be the first district to use the state system. Thereafter, the courts in the appellate judicial districts surrounding Cleveland, Columbus, Toledo, Dayton, and Akron were added to the system. However, since it was also assumed that, as these cities connected to the state system they also developed their own local SJIS system for calendar management and court record keeping, these court systems are included as single large terminals in the major cities rather than individual terminals in each of the courts. It is likely that the state system would interface with a court computer in each of the major appellate judicial districts or major metropolitan areas rather than directly with the individual courtroom terminals.

Conversations with data processing officials in Ohio's correctional institutions revealed that their connection to the state CCH/OBTS files would not likely occur for some years. The Ohio Department of Rehabilitation and Corrections had once operated an on-line data processing system but it was taken out a few years ago in the interests of economy. The Department presently has a system that is operated in a batch mode and this will likely remain the technique for inmate tracking for the next few years. However, to be complete in the STACOM study, it was decided to show the inclusion of the corrections institutions in the state network about midpoint in the decade being studied. At that time the headquarters office and several facilities throughout the state are assumed to be able both to inquire and to update the state CCH/OBTS files.

It has been pointed out that systems like an SJIS system are already operating in a few of the large Ohio cities - at least these systems have elements like an SJIS system in that they assist in the efficient operation of the courts of Hamilton or Lucas Counties, for instance. After discussing this topic with Ohio officials, it was decided to include an SJIS system in the STACOM network, but only on the level of transmitting judicial statistics to the Supreme Court Administrative Director. Discussions with the STACOM staff and Ohio officials suggested that, to be as realistic as possible, the SJIS functions of court management and record keeping would likely be retained at the local level during the period of the STACOM study, since some of them are already operating in that mode at the present time, but that a need did exist for statistics to be sent to the state that could be made more efficient by automatic data processing, especially since large computer installations would likely exist at each end of the transmission path anyway. It was estimated that cities like Cincinnati or Toledo would likely be the first to connect to and use such a system, and that only the appellate judicial districts surrounding the six largest cities would be included in the network by the end of this study period.

Just as the corrections institutions were assumed to be users of the CCH/OBTS system after a few years, they were also estimated to have implemented an on-line OBSCIS system at about the same time. It has been pointed out that such a system of inmate tracking is operated in a batch mode at the present time, but that it is not likely to be placed on-line for a few years. Even though its implementation is uncertain, it was included in the Ohio STACOM system for completeness, and because team discussions with Ohio officials indicated that such a system has not categorically been ruled out for the time period of this study. On the contrary, if funding is available, the state has every intention of implementing such a system.

Ohio is not yet involved in processing fingerprints by automatic pattern recognition equipment, and state officials currently believe that there are many smaller jurisdictions that will never have the fingerprint traffic volume to justify automatic fingerprint processing facilities. Instead, they see a three-tier arrangement of fingerprint processing in the future - and within the time horizon of the STACOM study: A few large cities will probably convert manual fingerprint processing to computerized systems within the next several years. However, just as in the case of the courts, this will probably be confined to only the largest five or six metropolitan areas. Gradually, these cities will probably begin sending fingerprints to state files already compressed and classified so that they can be sent over the same lines that will be carrying criminal history and court information. Another group of jurisdictions will not be able to afford or justify the expense of automatic fingerprint processing equipment, but they will be able to purchase high quality, rapid facsimile transmission machines for sending fingerprints to the state files over a network separate from the state criminal information system. This separate network is anticipated because of the large volume of data in an unprocessed fingerprint card and the need to send the data at a high rate if card transmissions are to occur in a reasonable amount of time - say, a few minutes. These separate lines could be dedicated to facsimile transmission between large cities, or they could be portions of other communications systems such as community antenna television (CATV) networks or dial-up communication lines. For purposes of the STACOM study in Ohio, therefore, the discussions with state officials suggested that this analysis should only include the processed fingerprints from the largest cities on the state network that would also carry the other types of criminal justice information. Finally, smaller rural communities will still likely continue to mail fingerprint cards into state files throughout the period of this study since their volume does not justify even a facsimile machine.

The managers of the Ohio state criminal files estimate that traffic from their data conversion operation to the state files will likely remain at the 1977 level throughout the decade of the STACOM study. This level is anticipated to be maintained because the department has reached its maximum expected staffing, and because, if criminal activity increases as expected, entries will gradually be made directly from users in the field rather than from the central state data conversion facility. The estimates of the state officials for traffic from this central BCII facility were then those used throughout the decade of this study.

4.4 DATA ANALYSIS TECHNIQUES AND NEW DATA FORECASTING METHODOLOGY

4.4.1 General Methodology

The components of new data that were estimated through 1985 are the nine listed in Section 4.1. Section 4.4 describes the approach taken to predicting new data type traffic in the two model states. The calculations based on these techniques and the results of the calculations are given in Section 6. The procedure that was used to analyze the data gathered from the model states and to estimate future traffic was:

(1) Determine average messages per day for each component of traffic for the entire state between the user agencies and the central files

(2) Compute an average message length for each new data component for messages to and from the state files, and an average for both directions combined

(3) Determine the aggregate peak characters per minute for each component of new data for traffic to and from the state center to the users

(4) Distribute the aggregate traffic in peak characters per minute to and from the state files between the individual users of the system so that traffic volumes to the localities throughout the state can be determined.

This process is shown schematically in Figure 4-1. The following paragraphs describe how this process worked for each of the components of new data types.

4.4.2 Arrest-Dependent Traffic

4.4.2.1 CCH/OBTS.

4.4.2.1.1 Average Messages Per Day. Aggregate statewide CCH/OBTS traffic was determined by estimating the total criminal activity in future years, determining how many offenders flow through each step of the criminal process from the criminal procedure diagram of Figure 4-2, and estimating the information needs at each step from the message use matrix of Figure 4-3. This process is shown schematically in Figure 4-4.

A complete list of the factors used in computing future CCH/OBTS traffic is given below and the factors are explained in the following paragraphs:

Total Statewide CCH/OBTS Traffic in Average Messages per day =
Estimated statewide arrests per year
× Technology penetration factor
× Number of transactions with the CCH/OBTS files per arrest
× Number of messages per CCH/OBTS transaction
× Time conversion to convert from years to day

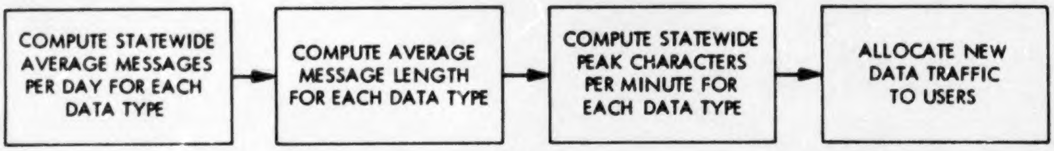

COMPUTE STATEWIDE AVERAGE MESSAGES PER DAY FOR EACH DATA TYPE
COMPUTE AVERAGE MESSAGE LENGTH FOR EACH DATA TYPE
COMPUTE STATEWIDE PEAK CHARACTERS PER MINUTE FOR EACH DATA TYPE
ALLOCATE NEW DATA TRAFFIC TO USERS

Figure 4-1. New Data Type Analysis, Forecasting and Distribution Methodology

(4) LINNUM Routine
This routine provides an estimated line configuration required to satisfy a given traffic and is mainly called upon by routine RGNNET. During its execution, utilization of selected lines are calculated against the given traffic by calling RHOFUN so that effective line utilization is less than the pre-determined number.

(5) RHOFUN Routine
This routine calculates the line effective utilization for a given traffic and line configuration.

(6) ICOSTJ Routine
Given the line configuration and indices for any two system terminations, this routine calculates the installation costs and annual recurring costs for the line and other chargeable items required. In calculating line costs, it calls upon routine DIST for distance data between two given system terminations. Resulting cost data are arranged by chargeable item type.

(7) DIST Routine
This routine retrieves distance data between any two system terminations by calling routine PACK. When the distance is greater than 510 miles, it retrieves distance data by calling routine RECOVR.

(8) PACK Routine
This routine stores or retrieves distance data between any two system terminations. It is called upon by routine MAIN for distance data depositing, and called upon by routine DIST for its retrieval. For the purpose of saving storage, distance data has been compressed, and each 36-bit word has been divided into four sub-words of 9 bits. Therefore, any distance datum with value equal to or greater than 511 is stored in another specified area; its retrieval calls upon routine RECOVR.

(9) RECOVR Routine
During distance data retrieval in the execution of the DIST routine, if the return value from routine PACK is 511, this routine will be called upon to provide the actual distance data, which is equal to or greater than 511.

(10) LINK Routine
Since the distance between any two system terminations I and J is independent of how I and J are referred to, the routine LINK provides a mechanism for preserving such an independency by mapping I and J into an absolute index.

(11) PLOTPT Routine
This routine provides instructions for plotting a given point on a CalComp plotter. Location of a point is calculated by its associated V-H coordinates.

7.1.9 Response Time Algorithm - RSPNSE Routine

There is a limit on the number of terminals which can be linked together by a multidropped line due to constraints on reliability and response time. However, it would be an oversimplification to just use a particular number as the main constraint in determining how many terminals a multidrop line can have. In reality, the response time of a given multidrop line depends on the amount of traffic, the number of terminals on the line, and very heavily, on the number of transactions to be processed in the data base computer system.

In the STACOM program, a response time algorithm is implemented in such a way that during the network optimization process it is used to accept or reject the addition of a given terminal to a multidrop line. This response time routine calculates the average response time on the given multidrop line, given the number of terminals and amount of peak traffic on the line. Before its inclusion in the STACOM program, the fidelity of this algorithm was evaluated by simulation and found to be acceptable.

7.1.10 Flexibility

At the outset of the STACOM project it was anticipated that the STACOM program would be used for states with varying traffic requirements; it was decided that the resulting program should be as flexible and general as possible. With this in mind, the STACOM program has been implemented with the following features which make it flexible and thereby enhance its capabilities:

(1) Rate Structures, Line Types, and Chargeable Items

Because a state can have more than one rate structure (tariff) applicable at any one time, the STACOM program has been designed to accommodate this.

Under a specific rate structure, any combination of line types with their names, line capacities, and basic cost figures can be prescribed to the program. In addition to the line cost, any number of chargeable items associated with each line type can be prescribed to the program. For example, any combination of cost items such as service terminals, drops, modem and others can be used. Furthermore, under the Multischedule Private Line (MPL) tariffs given by AT&T for interstate communication lines, the monthly line charge between any two terminals is now a function of both the inter-city distance and the traffic densities of both terminal cities.

The STACOM program has been implemented in such a way that it can take line-cost figures based on MPL tariffs or other tariffs.

(2) Region Formation, Switcher Selection, and Network Optimization.

Given a set of system terminations dividing them into regions can be performed in either of the following ways: the user can preassign some or all of the terminations into preselected regions, alternatively the user can let the program perform the region formation by simply providing the system centroid. Following the formation process, the STACOM program will start selecting regional switching centers for regions without a preassigned switching center. The process of regional network formation and its optimization will then follow.

(3) Number of Terminals per Multidrop Line and Average Response Time

It may be desirable to set a limit on the number of terminals on a multidrop line. In its implementation, the STACOM program takes this number from the user's input data as a constraint during its optimization process.

Besides the limit on the number of terminals allowed on a multidrop line, a good network design also requires a constraint on the average terminal response time on a multidrop line. The STACOM program allows a user to specify the limit on a run basis.

7.1.11 Programming Language

The STACOM program is implemented with the FORTRAN V language of UNIVAC systems, compiled with the EXEC-8 FORTRAN Preprocessor and mapped by its MAP processor.

7.1.12 Operating System Requirements

The EXEC-8 operating system of the UNIVAC 1108 computer has been used in the development of the STACOM program. The current edition of the STACOM program can only be executed under the EXEC-8 system. Furthermore, since a CalComp routine is linked with the program, the plotter must be part of the operating system. If such a hardware unit is not included in the system, the STACOM program must be updated to reflect this environment.

In addition, the current STACOM program has been designed with the feature that all the desired output be put into a FORTRAN file designated as 100. Before executing this program, a file with the name 100 must be assigned. Otherwise, regular WRITE unit 6 will be the destination output file, e.g., print output will go to the user's demand terminal when it is run as a demand job.

As an example, the following is a complete list of EXEC-8 control statements which need to be prepared or typed in after the run card for properly executing the STACOM program.

```
@ASG,UP 100
@SYM,P PUNCH$,,G9PLTF
@XQT File.Element
      ϟ
     (data)
      ϟ
@BRKPT 100
@FREE  100
@SYM   100,,T4
```

The @SYM,P command directs the resulting plot card images to a CalComp plotter designated G9PLTF. The last @SYM command directs print output to the slow hardcopy printer designated T4.

7.1.13 Functional Limitations

While the STACOM program has been designed and implemented with the intention that it be applicable as widely as possible, it does have certain limitations. These are due mainly to the limit of program size (sum of I and D bank) allowed under the EXEC-8 system for simplistic programs. The maximum program size allowed is 65k words per program. Although it is more convenient for later use to assign all parameters with maximum values as long as the overall program size is within limits, this results in greater expense in later use of the program due to the higher core-time product. Therefore, it is recommended that all parameters be set at values just high enough for anticipated use.

After setting parameter values, the STACOM program capabilities are then limited to these assigned values. If a run requires that certain parameter value be exceeded, the STACOM program must be recompiled and remapped.

7.2 SYSTEM RELIABILITY AND AVAILABILITY ANALYSIS

While cost may be a major concern in deciding the option for network implementation when several alternatives are available, the factor of system reliability (survival probability) and availability as a function of alternate option does deserve some considerations. The reliability and availability of a system not only depends on how the system is built up, it also depends on how each component of the system behaves as time passes by. In the following sections, we will present assumptions and definitions of terms and equations which are to be used later in calculating system reliabilities and availabilities. The constraints of subsystems to be investigated and results from applying these equations for both Ohio and Texas are then presented.

7.2.1 Assumptions

The true reliability (survival probability) of a given component as a function of age is impossible to describe exactly and simply. However, in many cases, a component's reliability can be practically and usefully represented as a unit with a "bathtub" shape failure rate function as shown in Figure 7-8. In other words, a component can be well described as having a failure rate that is initially decreasing during the infant mortality phase, constant during the so-called "useful life" phase, and, finally, increasing during the so-called "wear-out" phase.

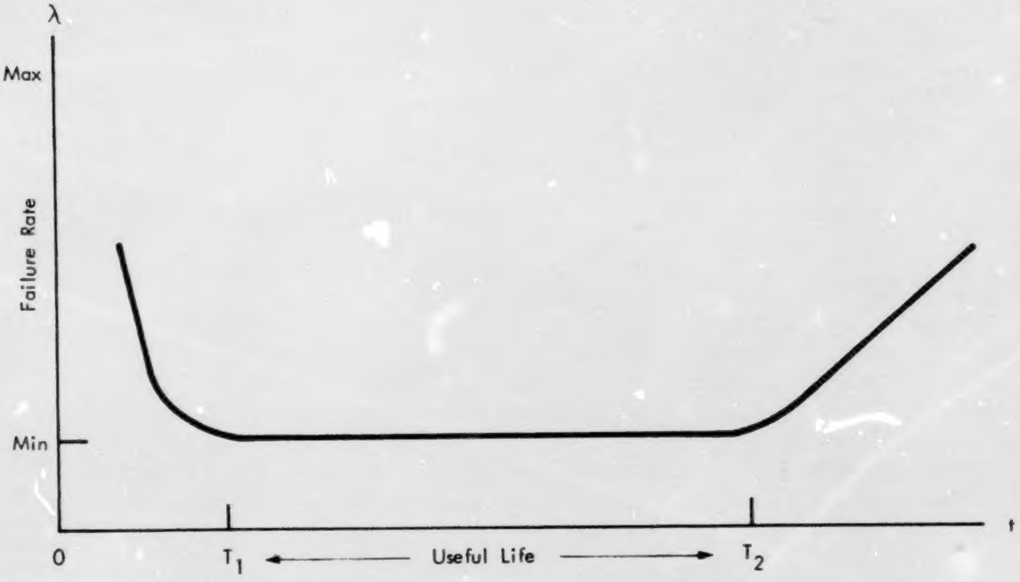


Figure 7-8. "Bathtub" Failure Rate Function

In this study, we assume that all components are to be operated within the constant failure rate phase. Several distribution functions do have such a constant failure rate case. However, in the following discussions, we use the exponential distribution to represent the reliability function for each individual component. An important property of the exponential distribution is that the remaining life of a used component is independent of its initial age (the "memoryless property"). With the exponential distribution it follows that:

(a) Since a used component is as good as new (statistically), there is no advantage in following a policy of planned replacement of used components known to be still functioning.

(b) The statistical estimation data of mean-life, percentiles, reliability and so on, may be collected on the basis only of the number of hours of observed life and of the number of observed failures; the ages of components under observation are irrelevant.

7.2.2 Definition

For the purpose of convenience in later discussions, we give definitions to the following terms and notations:

(a) λ_i = Failure rate for component i

(b) μ_i = Mean time between failures (MTBF) for component i

(c) ν_i = Mean time to repair (MTTR) for component i

(d) R(t) = Reliability function as a function of time, t

(e) A(t) = Availability function as a function of time, t

(f) A_{av} = The limiting average availability

(g) $\gamma_i = \nu_i/\mu_i$

(h) λ = System failure rate

(i) μ = System MTBF

(j) ν = System MTTR

7.2.3 System Reliability and Availability

Given a system with n (≥ 2) components, it is in general impossible to derive its exact reliability and availability. However, if the statistical interrelationship among its components can be described, we can then relate the system reliability and availability to the reliabilities and availabilities of the components. For the simplest case, if all of the components are statistically independent and each of them has a constant failure rate λ_i, then the overall system reliability R(t) for a series system (a system which functions if and only if each component functions) is

$$R(t) = e^{-\lambda t} \tag{1}$$

where $\lambda = \sum_{i=1}^{n} \lambda_i$

n = number of components in the system

If the system has a parallel structure (a system which functions if and only if at least one component functions), its reliability becomes

$$R(t) = 1 - \prod_{i=1}^{n} \left(1 - e^{-\lambda_i t}\right) \tag{2}$$

where denotes the multiplication operation.

Furthermore, for a series system, its limiting average system availability can be described as

$$A_{avg} = \left(1 + \sum_{i=1}^{n} \gamma_i\right)^{-1} \tag{3}$$

and the average of system downtime (MTTR) becomes

$$\nu = \mu \sum_{i=1}^{n} \gamma_i \tag{4}$$

where μ = system MTBF

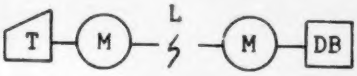
$$= \left(\sum_{i=1}^{n} 1/\mu_i\right)^{-1} = \left(\sum_{i=1}^{n} \lambda_i\right)^{-1} \tag{5}$$

7.2.4 System Reliability and Availability for the Ohio Network

7.2.4.1 Reliability System Structures. The communications network for Ohio currently consists of one central switcher with data bases and may have regional switchers in the future. The regional switchers serve as intermediate message switchers between local terminals and the central switcher. With this in mind, the reliability system structures from an individual user terminal can be described as follows:

Case 1 - One Central Switcher with Data Bases.

Figure 7-9 shows the reliability system structure for the user terminal when its communication with the data bases has to go through the central switcher directly.



where T = user terminal

M = Modem

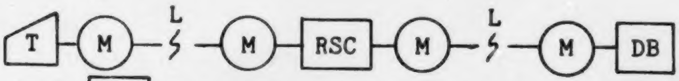
DB = Columbus data base computer, i.e., Univac 1100/42

L = communication line from the user modem to the central switcher modem

Figure 7-9. Ohio Reliability System Structure for Case 1

Case 2 - One Central Switcher with One Regional Switcher

In another configuration, the user terminal communicates with the central switcher with the data bases through the regional switcher. Its reliability system structure can be described as Figure 7-10.



Where RSC = Regional Switching Center

Figure 7-10. Ohio Reliability System Structure for Case 2

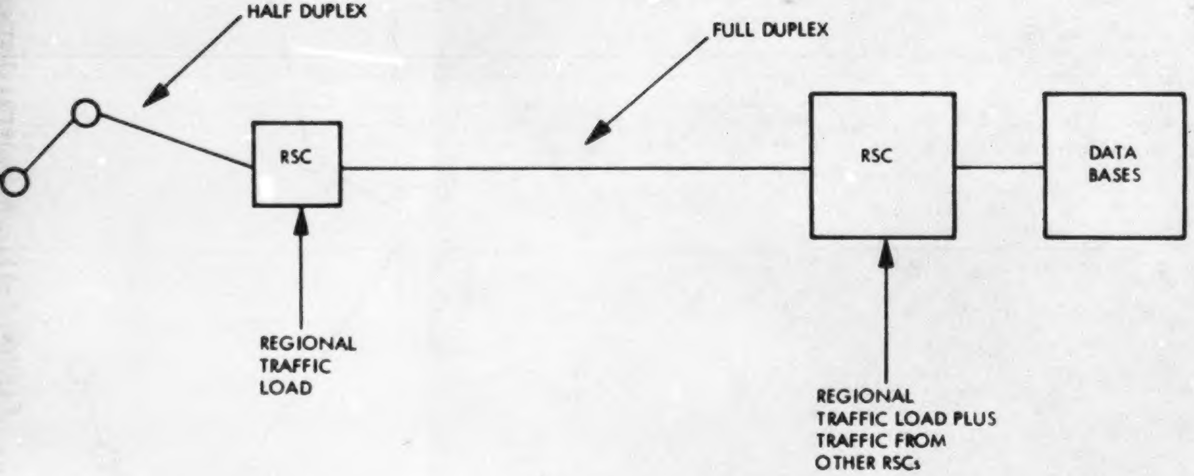

HALF DUPLEX
FULL DUPLEX
RSC
RSC
DATA BASES
REGIONAL TRAFFIC LOAD
REGIONAL TRAFFIC LOAD PLUS TRAFFIC FROM OTHER RSCs

Figure 7-12. Simplified Configuration For Response Time Analysis

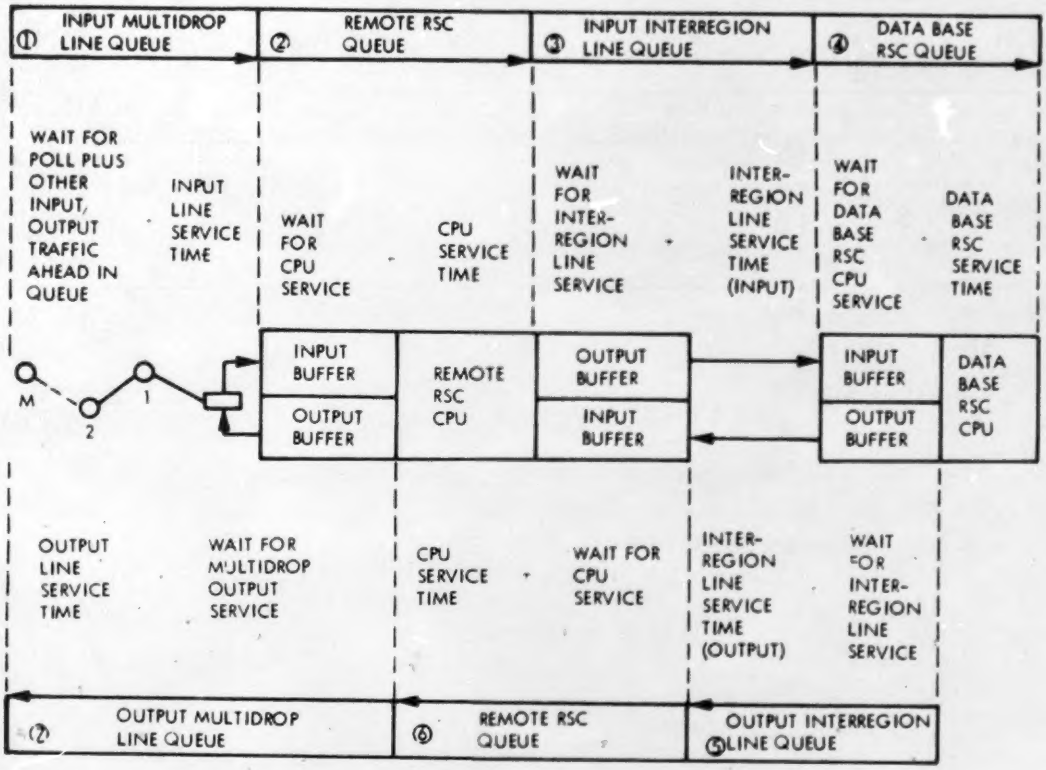

① INPUT MULTIDROP LINE QUEUE
② REMOTE RSC QUEUE
③ INPUT INTERREGION LINE QUEUE
④ DATA BASE RSC QUEUE
WAIT FOR POLL PLUS OTHER INPUT, OUTPUT TRAFFIC AHEAD IN QUEUE
INPUT LINE SERVICE TIME
WAIT FOR CPU SERVICE
CPU SERVICE TIME
WAIT FOR INTER-REGION LINE SERVICE
INTER-REGION LINE SERVICE TIME (INPUT)
WAIT FOR DATA BASE RSC CPU SERVICE
DATA BASE RSC SERVICE TIME
M
2
1
INPUT BUFFER
OUTPUT BUFFER
REMOTE RSC CPU
OUTPUT BUFFER
INPUT BUFFER
INPUT BUFFER
OUTPUT BUFFER
DATA BASE RSC CPU
OUTPUT LINE SERVICE TIME
WAIT FOR MULTIDROP OUTPUT SERVICE
CPU SERVICE TIME
WAIT FOR CPU SERVICE
INTER-REGION LINE SERVICE TIME (OUTPUT)
WAIT FOR INTER-REGION LINE SERVICE
⑦ OUTPUT MULTIDROP LINE QUEUE
⑥ REMOTE RSC QUEUE
⑤ OUTPUT INTERREGION LINE QUEUE

Table 7-13. System Message Queues

(5) No messages leave queues without first being serviced.

(6) Polling is cyclic on the multidrop with equal weighting for each terminal.

(7) Message handling is on a non pre-emptive basis, that is, messages are not interrupted once they are placed on a transmission line.

(8) When dual CPU's are considered, they are assumed to be evenly loaded.

(9) Users on the multidrop line do not hold the line for more than one message before polling is resumed.

Under conditions of the above assumptions, the mean waiting time, E(tw), in a single server queue is

$$E(tw) = \frac{\rho E(ts)}{1 - \rho} \qquad (1)$$

where $E(ts)$ = mean service time (sec)

and $\rho = E(n) \times E(ts)$

where $E(n)$ = average number of transaction arrivals per second

The mean queue time is therefore

$$E(tq) = E(tw) + E(ts)$$

or

$$E(tq) = \frac{\rho E(ts)}{1 - \rho} + E(ts)$$

or simplified

$$E(tq) = \frac{E(ts)}{1 - \rho} \qquad (2)$$

The term, ρ, is a measure of facility utilization and is equal to the fraction of time that a facility is in use serving transactions. The term, ρ, takes on values betwen 0 and 1. When $\rho = 1$ it means that the facility is 100% utilized. We shall see that ρ values should generally not exceed 0.700.

For dual server queues, such as computers with twin processors where an incoming transaction is serviced by the first processor which is not busy, the waiting time for service, E(tw), is given by

$$E(tw) = \frac{\rho^2}{1 + \rho} \; \frac{E(ts)}{1 - \rho} \qquad (3)$$

and in this case the traffic value, E(n), should be halved in calculating ρ; that is

$$\rho = \frac{E(n)}{2} E(ts)$$

Before presenting specific equations for the queues outlined in Figure 7-13, we shall consider the general equations for waiting times when it is desired to handle messages of different priority types.

The ability to prioritize messages can be an important network feature when there is a mixture of long and short messages on the network, that is, when there is a wide range of average message lengths for different message types. For example, in the law enforcement environment, when long message types such as digital fingerprint data, Computerized Criminal History data, digital facsimile data or long administrative messages are included in a network along with shorter inquiry/response messages related to officer safety, it may be expedient to transmit the latter message types with a higher priority over the network to insure shorter response times for these more important message types.

The response time model is capable of handling up to four message priority levels. The mean wait time components of mean queue times for the four priority levels are given below. Priority 1 is the highest priority.

- Mean wait time, Priority 1,

$$E(tw1) = \frac{\rho E(ts)}{1 - \rho_1} \qquad (4)$$

Mean wait time, Priority 2,

$$E(tw2) = \frac{\rho E(ts)}{(1 - \rho_1)\,(1 - \rho_1 - \rho_2)} \qquad (5)$$

Mean wait time, Priority 3,

$$E(tw3) = \frac{\rho E(ts)}{(1 - \rho_1 - \rho_2)\,(1 - \rho_1 - \rho_2 - \rho_3)} \qquad (6)$$

Mean wait time, Priority 4,

$$E(tw4) = \frac{\rho E(ts)}{(1 - \rho_1 - \rho_2 - \rho_3)\,(1 - \rho)} \qquad (7)$$

In the above equations

ρ_i = facility utilization due to priority i message type
i = 1, 2, 3, 4

and $\rho_i = E(n_i) \times E(ts_i)$

where $E(n_i)$ = arrivals per second of priority i type messages

and $E(ts_i)$ = service time for priority i type messages

so that the total facility utilization

$$\rho = \rho_1 + \rho_2 + \rho_3 + \rho_4$$

and the total message arrivals per second

$$E(n) = E(n_1) + E(n_2) + E(n_3) + E(n_4)$$

Finally, in the model, there are two types of service times to be calculated. One is service time for message transmission over communication line facilities and the other is service time for message switching and data base acquisition by computer facilities.

For the four priority types, service times for messages on communication lines are given by

$$E(tsi) = \frac{(Lmi + OH) \times Bc}{C} + MPSE \qquad (8)$$

where i = 1, 2, 3, 4,

and Lmi = average message length of a priority i type message in characters

OH = number of overhead characters that accompany a message on the network

Bc = number of bits per character

C = line capacity in Bauds

MPSE = time spent for pauses in transmission due to modem line turnaround time or other factors

The unsubscripted service time term, E(ts), (which appears with the unsubscripted ρ term in the numerators of equations 4 thru 7), is calculated similarly, but uses the overall network average message length, Lm, in place of Lmi,

$$Lm = P_1(Lm1) + P_2(Lm2) + P_3(Lm3) + P_4(Lm4)$$

where P_i = the percentage of priority i type messages on the network $i = 1, 2, 3, 4$

The mean service time for a negative poll on the multidrop network is given by

$$E(tPOLL) = \frac{POH \times Bc}{C_m} + PPSE \qquad (9)$$

where POH = number of polling characters including overhead characters

Bc = number of bits per character

C_m = line capacity in Bauds

PPSE = total line pauses during a negative poll due to modem turnarounds, etc. There are two line turnarounds for a negative poll on a half duplex line.

Note that communication line service times do not include terms accounting for line transmission delays as a function of distance. These contributions to total response time are negligible and are not included in the model.

Mean service times for computers are estimated from data supplied by computer system vendors. Of interest is the average time required to process a transaction. For an RSC the time is that required to perform message switching. For a remote single server RSC, the mean queue time E(tqRC), is

$$E(tqRC) = \frac{E(tsRC)}{1 - \rho_{RC}} \qquad (10)$$

where E(tsRC) = mean service time for switching per transaction in a regional computer

ρ_{RC} = facility utilization for a regional computer

and $\rho_{RC} = E(nRC)\ E(tsRC)$

where E(nRC) = total transaction arrivals per second at the regional RSC

For an RSC connected to a data base, we shall assume that the computer is a dual processor so that it behaves as a dual server queue. In this case, the mean queue time for the data base switcher computer, E(tqCD), is

$$E(tqCD) = \frac{\rho_{CD}^{2}}{1 + \rho_{CD}} \; \frac{E(tsCD)}{1 - \rho_{CD}} + E(tsCD) \tag{11}$$

where E(tsCD) = mean service time for switching plus data base access per transaction

ρ_{CD} = facility utilization for an RSC with data base

and $$\rho_{CD} = \frac{E(nCD)}{2} E(tsCD)$$

where E(nCD) = total transaction arrival rate per second at the data base RSC

Mean service times for computers are hardware and software configuration dependent, which necessitates vendor consultation in each case. Generally, computer mean service times will range from 100 ms to 700 ms.

In arriving at values for computer mean service times, it is important to visualize the computer facility as a single large queue, despite the fact that the operating system may involve many queues in reality. One approach, for example, may consider the mean number of program steps executed per transaction and the mean number of disc accesses per transaction. Typical numbers may be:

ITEM	SPEED	TIME
150,000 instructions per transaction	@ 1 microsecond mean instruction execution time	0.150
6 disc accesses per transaction	@ 47.5 milliseconds per access	0.285
	MEAN COMPUTER SERVICE TIME =	0.435 sec

Ideally, vendors or system users may have actual measurements available from operating statistics.

7.3.1.3 Inputs/Outputs. The general model requires the input data listed in Table 7-3. Table 7-4 describes the terms calculated by the model. Figure 7-14 clarifies where various terms apply in the model.

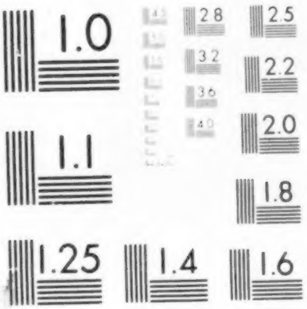
Once the calculated values are found, it is a simple matter to sum up the desired components of the seven queues involved, (outlined in

Figure 7-13), to arrive at desired values for response times by priority type. It is also possible to use the model for simpler network configurations which may or may not involve message prioritization. The following two examples will clarify model use.

Table 7-3. Model Inputs

Item	Symbol	Meaning and Units
1	Cm	Line capacity of the multidrop (Baud)
2	CR	Line capacity of interregion line (Baud)
3	OH	Overhead characters in line protocol (CH)
4	MPSEM	Total line turn-around time on multidrop (sec)
5	MPSER	Total line turn-around time on interregion line (sec)
6	M	Number of terminals on multidrop
7	UC	Units per character (bits)
8	L_1	Priority one output average message length (CH)
9	L_2	Priority two output average message length (CH)
10	L_3	Priority three output average message length (CH)
11	L_4	Input average message length (CH)
12	L_5	Priority one input average message length (CH)
13	L_6	Priority two input average message length (CH)
14	L_7	Priority three input average message length (CH)
15	Lm	Overall system average message length (CH)
16	E(nm1)	Mean arrival rate of priority one output messages to multidrop (msg/sec)
17	E(nm2)	Mean arrival rate of priority two output messages to multidrop (msg/sec)
18	E(nm3)	Mean arrival rate of Priority 3 output messages to multidrop (msg/sec)

NIL


1.0
4.5
5.0
5.6
6.3
7.1
8.0
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.1
1.8
1.25
1.4
1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Table 12-14. Network Line Characteristics (Continuation 1)

Network LEADS Number of Regions 4

Remarks Toledo as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	35	21	1200	0.449	192	8.5
2	13	5	2400	0.460	0	5.7
3	179	2	1200	0.043	10	6.2
4	371	25	1200	0.436	190	8.7
5	175	15	1200	0.351	85	7.8

Network LEADS Number of Regions 4

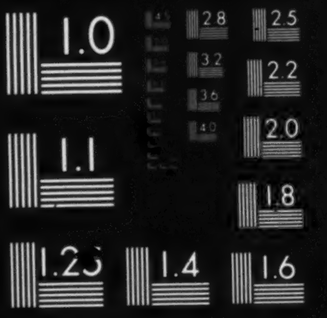
Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	370	22	1200	0.595	148	7.0
2	422	9	2400	0.649	0	5.3
3	353	17	1200	0.332	163	5.9
4	308	14	1200	0.251	122	5.5
5	295	24	1200	0.519	241	6.9
6	95	16	1200	0.468	142	6.2

Table 12-19. Network Option Costs (Thousands of Dollars)

Network Integrated LEADS/PMV Number of Regions 1
Remarks Single Network

Item	No. Reqd.	Recurring Costs			One Time Installation Costs		Total Eight Year Cost by Item
		Annual Cost Each	Total Annual Cost	Eight Year Cost	Unit Cost	Total Purchase Cost	
Lines, Modems Service Terminals	-	-	790	6,320	-	68	6,388
Terminals	390	0.6	234	1,872	3.6	1,400	3,272
Regional Switchers							
Switcher Floor Space							
Switcher Back-up Power							
Switcher Personnel							
Engineering					-	130	130
Subtotals			1,024	8,192		1,598	9,790
				Total Eight Year Cost			9,800


1.0
4.5
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Table 12-14. Network Line Characteristics

Network LEADS Number of Regions 4

Remarks Cincinnati as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	322	14	1200	0.276	154	7.5
2	172	3	2400	0.423	49	5.5
3	323	3	2400	0.584	0	6.6
4	148	13	1200	0.465	106	7.9
5	338	20	1200	0.530	116	8.6

Network LEADS Number of Regions 4

Remarks Cleveland as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	54	6	4800	0.417	0	4.0
2	242	19	1200	0.478	55	8.4
3	60	15	1200	0.408	81	8.0
4	51	16	1200	0.370	62	7.9
5	200	17	1200	0.439	75	8.2
6	229	17	1200	0.549	73	8.5
7	294	18	1200	0.549	140	8.6
8	269	7	1200	0.446	67	7.5
9	43	4	2400	0.349	31	5.1
10	260	22	1200	0.493	112	8.7

Table 12-15. Terminal Assignments

```
NETWORK OPTION:  BMV

NUMBER OF REGIONS:  1

                                 TERMINALS
           LINE   TOTAL
REGION      NO.    NO.   STARTING                  REMAINING
  1
             1     24       435
                                   436,645,644,578,598,439,440,441,454,453,
                                   448,449,450,652,451,452,653,655,656,657,
                                   654,455,442,
             2     25       643
                                   565,566,567,568,666,665,664,579,659,660,
                                   580,581,582,584,585,586,587,588,599,600,
                                   601,602,603,569,
             3     18       649
                                   445,437,438,646,590,591,592,593,594,595,
                                   596,662,663,647,661,446,650,
             4     22       552
                                   668,479,669,670,671,489,571,672,572,651,
                                   573,574,575,576,635,636,637,638,639,673,
                                   674,
             5     21       467
                                   468,469,470,471,459,473,474,472,460,462,
                                   461,546,547,548,464,465,463,475,476,477,
             6     23       444
                                   487,533,562,563,564,641,642,480,553,554,
                                   555,557,556,558,559,560,534,457,541,542,
                                   543,544,
             7     25       458
                                   545,524,525,535,536,537,515,526,527,528,
                                   538,539,549,550,516,517,518,519,529,530,
                                   531,520,521,522,
             8     23       508
                                   507,620,621,622,623,628,629,636,631,632,
                                   633,613,614,615,513,606,607,609,610,611,
                                   616,605,
             9      6       488
                                   490,491,493,492,675,
            10     25       481
                                   482,506,502,497,498,499,500,501,509,510,
                                   511,512,503,504,617,618,484,483,494,495,
                                   485,624,625,626,
```

Table 12-16. Network Option Costs
(Thousands of Dollars)

Network BMV
Number of Regions 1
Remarks Optimized Separate BMV Network

Item	No. Reqd.	Recurring Costs			One Time Installation Costs		Total Eight Year Cost by Item
		Annual Cost Each	Total Annual Cost	Eight Year Cost	Unit Cost	Total Purchase Cost	
Lines, Modems Service Terminals	-	-	193	1,544	-	30	1,574
Terminals							
Regional Switchers							
Switcher Floor Space							
Switcher Back-up Power							
Switcher Personnel							
Engineering					-	130	130
Subtotals			193	1,544		160	1,704
				Total Eight Year Cost			1,700

12.7.3 Line Performance

Line performance data for each of the ten 1200 Baud lines for the BMV Network is presented in Table 12-17. Mean response time at all terminals is fairly constant varying from 4.1 to 5.1 seconds with the exception of line 9 which is comprised of only six terminals each of which has a mean response time of 2.1 seconds.

Table 12-17. Network Line Characteristics

Network BMV Number of Regions 3

Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	435	24	1200	0.218	334	4.8
2	643	25	1200	0.287	191	5.0
3	649	19	1200	0.273	215	4.1
4	552	22	1200	0.312	234	4.6
5	467	21	1200	0.150	347	4.3
6	444	23	1200	0.273	199	4.7
7	454	25	1200	0.304	253	5.0
8	508	24	1200	0.384	231	4.9
9	488	6	1200	0.059	121	2.1
10	481	25	1200	0.450	219	5.1

12.7.4 Network Availability

The network availability for the single region BMV network is calculated at 0.988 which corresponds to a daily average outage of 17.3 minutes per day.

12.8 OPTION 6 - AN INTEGRATED LEADS AND BMV NETWORK

12.8.1 Topology

The integrated LEADS and BMV Network is shown in Figure 12-6. The network is comprised of a single region with 30 multidropped lines out of Columbus. In general, there is a mix of terminals on these lines serving law enforcement agencies and BMV offices. Table 12-18 details terminal assignments to each of the 30 lines by PID number. There are two 4800 Baud lines in the network and four 2400 Baud lines in the network and four 2400 Baud lines. The remaining lines are 1200 Baud lines.

12.8.2 Costs

Total 8 year costs for the integrated LEADS BMV Network are shown in Table 12-19. The total cost is $9,800,000. These comparative costs include LEADS terminals as did the single region LEADS network costs, but not the already acquired BMV terminals. Lines, modems and service terminals amount to 64% of total costs as presented.

The integrated network was optimized subject to the MPL tariff discussed in Section 9 of this report since the LEADS Network qualifies as an inter-state network.

12.8.3 Line Performance

Line performance data for the integrated LEADS BMV Network is presented in Table 12-20. Mean response time at terminals varies between 1.7 and 7.2 seconds. Message prioritization is not required to meet these response time values.

12.8.4 Network Availability

The network availability to any terminal on the integrated LEADS BMV Network is 0.988, which implies a daily average outage of 17.3 minutes.

12.9 OPTION 7 - NEW DATA NETWORK SEPARATE FROM LEADS

12.9.1 Topology

Growth of new data types is such that a new data network separate from the LEADS network should be constructed in two phases. An interim network to handle traffic through 1980 is shown in Figure 12-7. A complete network sufficient to handle predicted new traffic volumes from 1981 through to 1985 is shown in Figure 12-8. Both networks are basically starred networks with some lines involving a drop consisting of two terminals. Table 12-21 lists cities included in the network which functions through 1980 and whose PID numbers were used in the computer runs. Table 12-22 lists terminals for the final new data network to function from 1981 through 1985. The first network employs nine lines in total and the second network adds six new lines as shown.

12.9.2 Costs

Total eight year costs for the separate new data network amount to $724,000 as shown in Table 12-23. Costs for lines, modems, service terminals and network terminals are broken out for required network phasing. It is assumed that the first network is built in 1978 and the second in 1981. As in previous costing, new terminals for the network are purchased.

12.9.3 Line Performance

Line performance characteristics for the 1985 new data network are shown in Table 12-24. Response time varies from 2.2 to 14.2 seconds. These response times are in keeping with functional requirements for response times for these data types.

Table 12-18. Assignments by PID Number

```
NETWORK OPTION:  LEADS WITH HRV

NUMBER OF REGIONS:  1

                                        TERMINALS
              LINE   TOTAL
REGION         NO.    NO.   STARTING                    REMAINING
   1
               1      9         64
                                         354,609,247, 63,610,249,611,608,
               2     25        220
                                         225,303,265,620,621,622,623, 56,241,200,
                                         230, 38,242,233,243,544,226, 55,219,223,
                                         224,216,221,396,
               3     12         54
                                         235,231, 52,238, 59,628,629,630,631,632,
                                         633,
               4     17         60
                                         397,616,388,232,237,387,605,248, 61,252,
                                         409, 62,606,245,246,607,
               5     21        196
                                         491,189,190, 29,493,188,205,494,204,483,
                                         203,209,495,208,485,195,187,192, 31,675,
               6     18        408
                                         407, 67,508,194,488,198,302,490,185,184,
                                          37,481,191,197, 34,482,507,
               7     25        385
                                         202,201, 47,484,212,389, 48,211, 49,617,
                                         618, 44,391, 50,390,624,625,626,236,206,
                                         207,210, 51,395,
               8     10         43
                                          42, 41,406,497,498,499,500,501,509,
               9     23        402
                                         255,257,266,502,256,258,262,259,261,263,
                                         267,510,511,264, 71, 70,512,147,403,260,
                                         239, 72,
              10     25        400
                                         401, 68,506,215,214, 40,503,410,504,250,
                                         229, 58,244,217,613,614,615,222,218,513,
                                         596, 57,234,254,
              11     25         24
                                         155, 18,449,450,368,652,178,179, 22,651,
                                         575,162,451,164,165, 20,452,156,653,359,
                                          21,655,363,654,
              12     25        336
                                         436,138,142,437,438,152,251,139,646,151,
                                         351,115,647,339,663,344,140,439,149, 16,
                                         440,150, 25,441,
              13     15        335
                                         328,117,435,346,345,445,343,340,330,110,
                                         578,329,349,645,
              14     24        353
                                         416,417,565,566,104,567, 98,598,334,111,
                                         579,331,664,665,321, 99,666,325,100,568,
                                         324,569,322,
              15     14         95
```

Table 12-18 (Continuation 1)

			367,552,668,365,364, 45,669,376,479,414, 108,109,643,
16	9	146	333,113,114,112,590,591,592,593,
17	18	323	107, 12,659,660,590,581,592,584,585,586, 587,588,599,600,601,602,603,
18	10	13	26,173, 34,168,576,635,636,637,638,
19	23	357	356, 27,670,379,378, 28,671,183,489,186, 492, 30,382,377,674,371,180,181, 32,673, 358,571,
20	25	383	380,672,169,572,141, 23,182,574,171,171, 33,175,170,179,176,639,172,575, 35,362, 657,360,361,656,
21	22	366	161,649,157, 17,446,447,163,154,650,160, 166,448,159, 19,453,454,144,145,442,158, 455,
22	19	644	116,332,143,350,352,544,348,338,595,341, 596,102,318,101,662,319,148,661,
23	23	290	527, 83,516,283,280,276,277, 84,275,274, 295,517,518,519,529,530,531,273,520,521, 278,279,
24	13	370	381,534,295,457,541,542,543, 76,423,415, 544,414,
25	17	422	228,105, 46, 36, 85,337,421,347,444,487, 533,562,563,564,641,642,
26	25	292	461, 81,462,464,465,375,463,374,373, 80, 549,550,372,539,289, 82,538,296,528,272, 271,270, 73,522,
27	23	303	469,311,309, 77,458,470,471,312,304, 78, 459,298,545,399,524,404,405, 92,473,474, 472,460,
28	23	418	96, 86,553,412,413, 88,554,320,315,555, 420, 89,557,556,316,314, 90,558,317, 94, 559,560,
29	23	74	75,535,536,537,286,297,287, 79,547,546, 284, 69,282,525,269,515,291,281,288,548, 294,526,
30	17	480	308,300,301, 87,467,302,468,305,306,307, 91,310,475,476, 93,477,

Table 12-20. Network Line Characteristics

Network LEADS with BMV

Remarks Under MPL

Number of Regions 1

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Tim (sec)
1	64	9	1200	0.156	192	4.7
2	220	25	1200	0.636	175	7.1
3	54	12	4800	0.460	126	2.0
4	60	17	1200	0.394	171	5.8
5	196	22	2200	0.390	158	6.2
6	408	18	1200	0.376	126	5.8
7	385	25	1200	0.623	157	7.1
8	43	10	2400	0.419	110	3.3
9	402	23	1200	0.448	172	6.4
10	400	25	1200	0.513	160	6.7
11	24	25	1200	0.467	211	6.6
12	336	25	1200	0.460	143	6.6
13	335	15	1200	0.437	83	5.8
14	95	24	1200	0.362	202	6.2
15	146	14	1200	0.265	56	5.3
16	146	9	2400	0.465	66	3.6
17	323	18	2400	0.681	101	5.7
18	13	10	2400	0.515	120	3.9
19	357	22	1200	0.379	166	6.1
20	383	25	1200	0.439	193	6.5
21	366	22	1200	0.273	154	5.9
22	644	19	1200	0.700	142	6.9
23	290	23	1200	0.561	178	6.7
24	370	13	1200	0.300	40	5.3
25	422	17	4800	0.356	0	1.7
26	292	25	1200	0.532	216	6.8
27	303	23	1200	0.312	242	6.0
28	418	23	1200	0.359	162	6.1
29	74	23	1200	0.693	192	7.2
30	480	17	1200	0.257	110	5.5

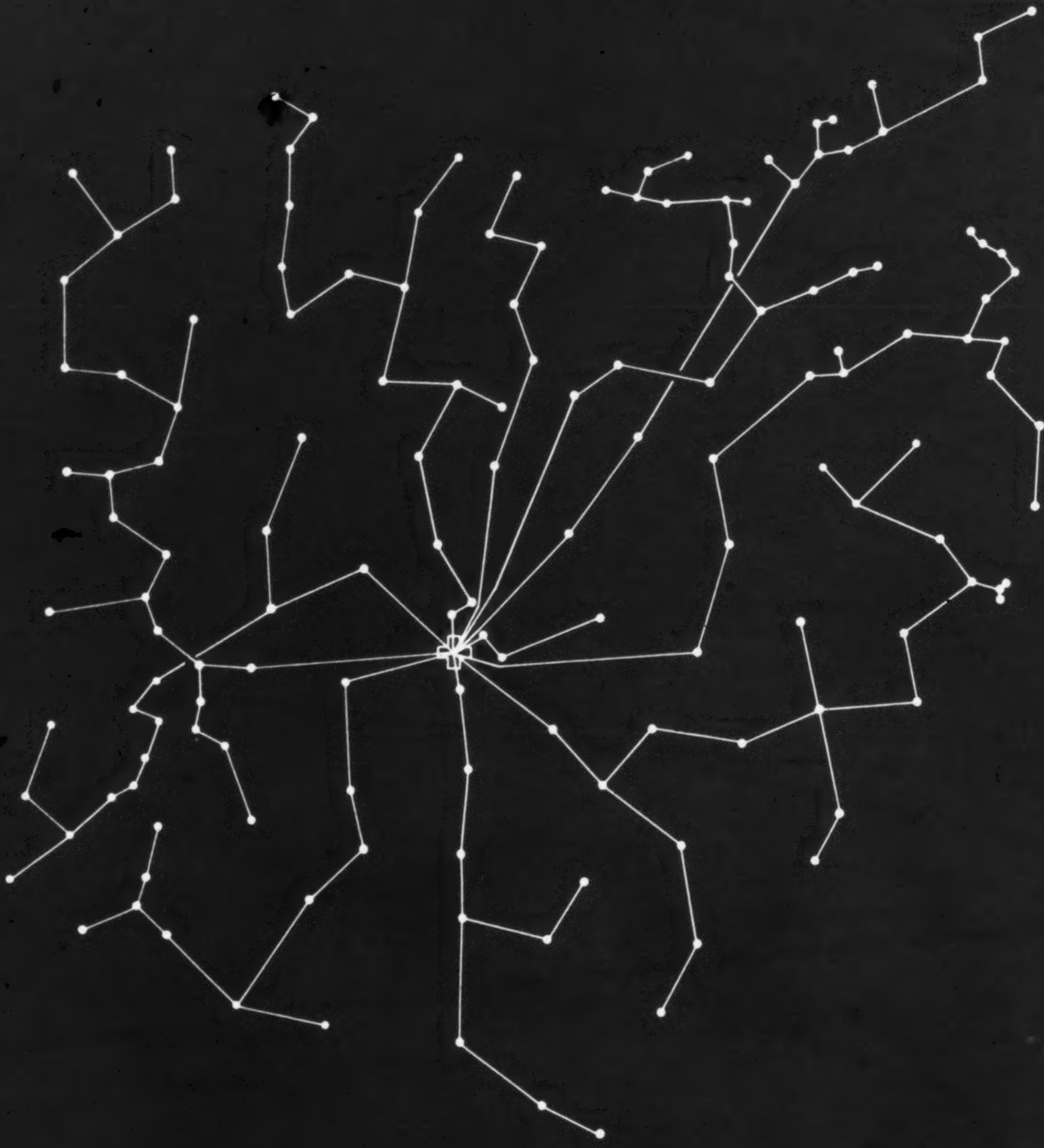


Figure 12-5. BMV Network

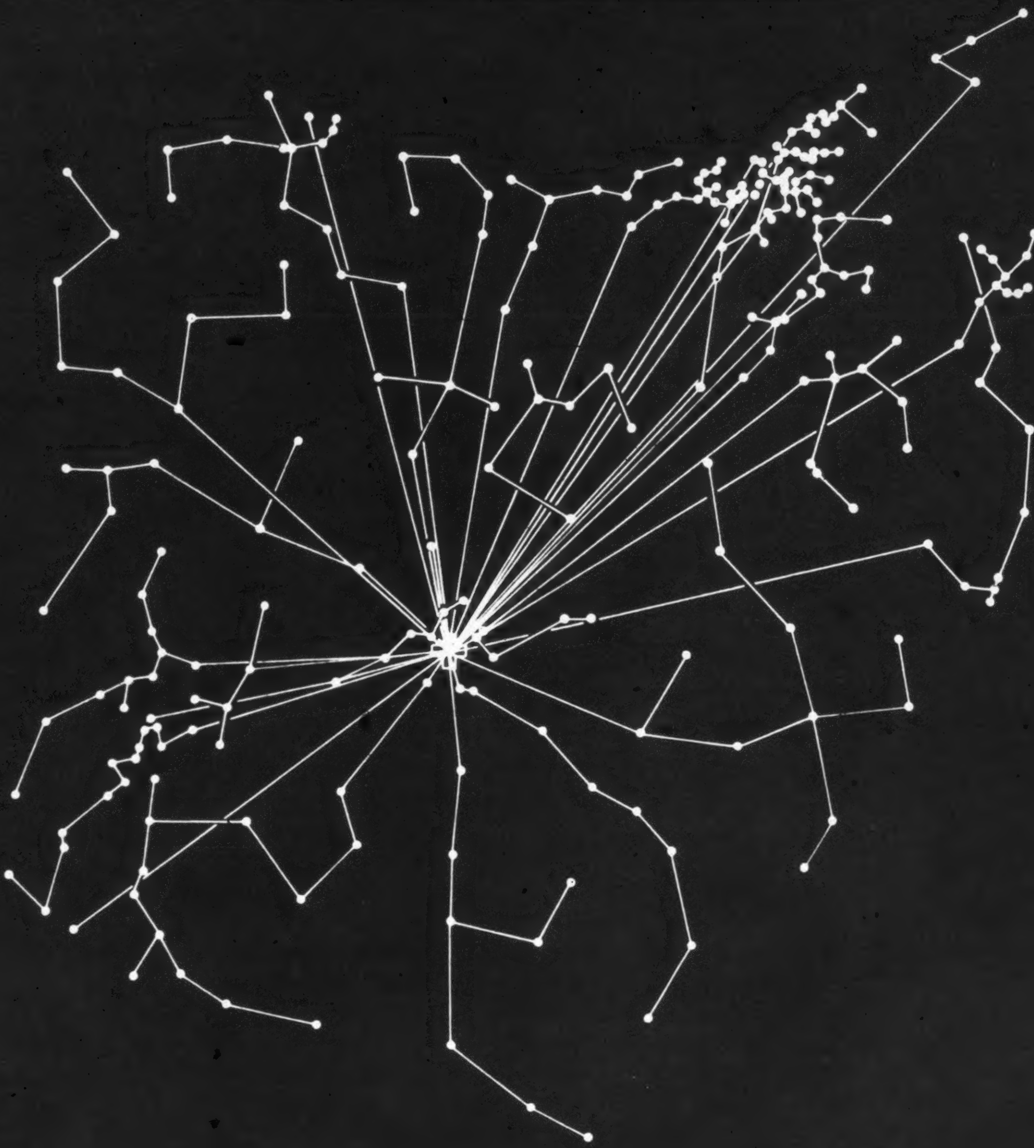


Figure 12-6. Integrated LEADS and BMV Network

Table 12-21. Separate New Data Network Terminal Assignments Through 1980

Line No.	First PID No.	Remaining PID Nos	Terminal Location
1	701		Dist 8 Courts, Cleveland
2	702		Dist 1 Courts, Cincinnati
3	703		Dist 2 Courts, Dayton
4	705		Dist 6 Courts, Toledo
5	707		ODC Headquarters
		706	Dist 9 Courts, Akron
6	708		Mansfield ODC
7	709		Columbus ODC
		704	Dist 10 Courts, Columbus
8	710		Marysville ODC
9	716		London BCI, Data Conv.

Table 12-22. Separate New Data Network Terminal Assignments 1981 Through 1985

Line No.	First PID	Remaining PIDs	Terminal Location
1	701		Dist 8 Courts, Cleveland
2	702		Dist 1 Courts, Cincinnati
3	703		Dist 2 Courts, Dayton
4	704		Dist 10 Courts, Columbus
5	705		Dist 6 Courts, Toledo
6	706		Dist 9 Courts, Akron
7	707		ODC Headquarters
		710	Marysville ODC
8	708		Mansfield ODC
9	709		Columbus ODC
10	711		Lebanon ODC
11	712		Lucasville ODC
12	713		London ODC
13	714		Marion ODC
14	715		Chillicothe ODC
15	716		London BCI, Data Conv.

Table 12-23. Network Option Costs (Thousands of Dollars)

work New Data Number of Regions 1
arks Optimized Separate New Data Network

tem	No. Reqd.	Annual Cost Each	Recurring Costs Total Annual Cost To 1980	1981-1985	Eight Year Cost	One Time Installation Costs Unit Cost	Total Purchase 1978	Cost 1981
s, Modems ice inals	-	-	50	78	540	-	4	4.3
inals	11/16	0.6	6.6	9.6	67.8	3.6	40	18
onal chers								
cher r Space								
cher up r								
cher onnel								
neering							40	10
otals			12	88	608		84	32

Total Eight Year Cost

Table 12-24. Network Line Characteristics

Network New Data Type Number of Regions 1
Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	701	1	9600	0.535	126	2.6
2	702	1	9600	0.499	101	2.4
3	703	1	9600	0.392	66	2.2
4	704	1	4800	0.689	0	5.9
5	705	1	4800	0.658	120	5.5
6	706	1	4800	0.619	110	5.1
7	707	2	2400	0.449	27	5.6
8	708	1	4800	0.641	61	5.3
9	709	1	4800	0.447	0	3.9
10	711	1	1200	0.469	74	14.2
11	712	1	1200	0.462	85	14.1
12	713	1	1200	0.383	25	12.7
13	714	1	1200	0.301	44	11.5
14	715	1	1200	0.279	44	11.2
15	716	1	9600	0.384	25	2.2

12.9.4 Network Availability

The network availability is 0.988, which implies an average daily outage of 17.3 minutes.

12.10 OPTION 8 - AN INTEGRATED LEADS AND NEW DATA NETWORK

12.10.1 Topology

Integration of new data type terminals into the LEADS network involves a two step implementation procedure as new data terminals are added to the network in the same manner that the separate new data type network implementation is phased (see Section 12.9). The network is basically the single region LEADS Network with the new data terminal star network added. The integrated network which serves through 1980 is identical with the exception that the five new data type terminals to be added in 1981 are absent from the network. The PID number of these five terminals are: 711, 712, 713, 714, and 715.

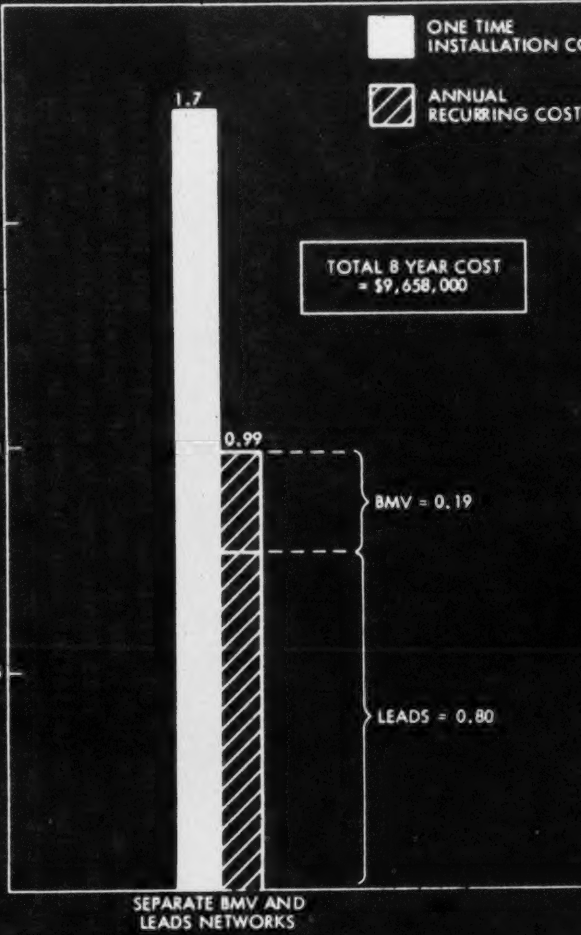
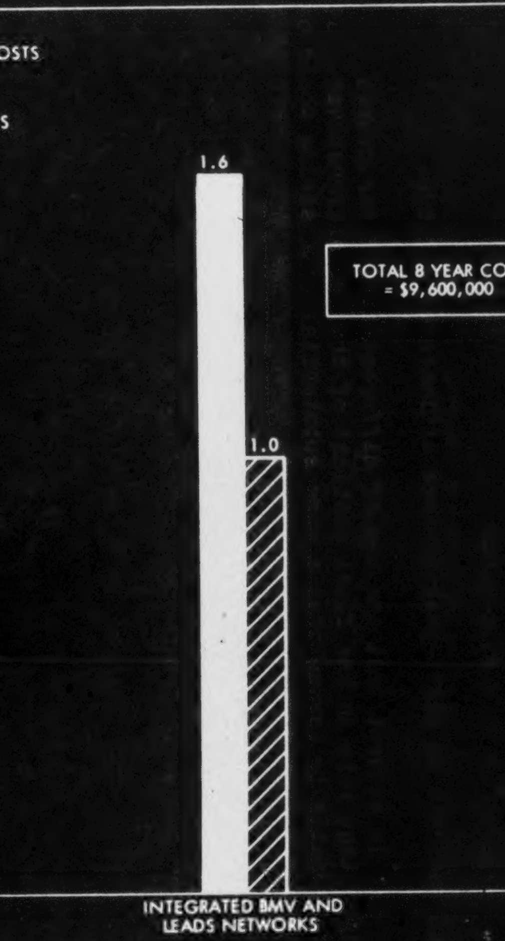


Figure 13-2. Separate



vs Integrated BMV and Leads Network

Table 12-25. Network Option Cos

Network Integrated Leads/New Data

Remarks Single Network

Numbe

Item	No. Reqd.	Annual Cost Each	Recurring Costs: Total Annual Cost To 1980	Recurring Costs: Total Annual Cost 1981-1985
Lines, Modems Service Terminals	-	-	598	638
Terminals	401/406	0.6	241	244
Regional Switchers				
Switcher Floor Space				
Switcher Back up Power				
Switcher Personnel				
Engineering				
Subtotals			839	882

ts (Thousands of Dollars)

er of Regions 1

s	One Time Installation Costs			Total Eight Year Cost by Item
Eight Year Cost	Unit Cost	Total Purchase 1978	Cost 1981	
4984	-	44	4.3	5032
1943	3.6	1444	18	3405
		130	10	140
6927		1618	32	8577

Total Eight Year Cost 8580

12.10.2 Costs

Total eight year costs for the integrated LEADS New Data Type Network are $8,580,000 as shown in Table 12-25. The phasing for line reconfiguration and addition of the five required terminals in 1981 is indicated.

12.10.3 Line Performance

Line performance for the integrated LEADS New Data Type Network is tabulated in Table 12-26. Response times vary from 1.2 seconds to 8.6 seconds. Line configurations are such that priorization of law enforcement message types is not required.

12.10.4 Network Availability

Network availability for the single region integrated LEADS New Data Type Network is 0.988, which implies an average daily outage of 17.3 minutes.

12.11 COMPILATION OF COST AND PERFORMANCE DATA - OPTION 1 THROUGH 8

Table 12-27 compiles cost and performance data presented for each of the eight options presented in this section. The next section discusses these findings and also presents results of additional network studies carried out in Ohio.

Network LEADS With New Data Type Number of Regions 1
Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	64	5	1200	0.122	192	5.4
2	54	6	4800	0.413	126	2.2
3	44	25	1200	0.669	186	8.6
4	229	22	1200	0.586	188	8.1
5	408	21	1200	0.490	158	7.6
6	385	23	1200	0.495	190	7.8
7	43	4	2400	0.350	110	8.5
8	400	25	1200	0.570	184	8.2
9	701	1	9600	0.547	126	1.4
10	708	1	4800	0.652	61	3.0
11	706	1	4800	0.629	110	2.9
12	365	20	1200	0.682	166	8.3
13	416	13	1200	0.697	180	7.8
14	353	23	1200	0.639	208	8.4
15	95	7	1200	0.524	41	6.7
16	146	5	2400	0.429	66	4.2
17	343	23	1200	0.485	165	7.7
18	323	3	2400	0.599	101	5.5
19	13	5	2400	0.456	120	4.3
20	116	15	1200	0.626	149	7.7
21	383	25	1200	0.536	256	8.1
22	366	3	2400	0.406	27	3.2
23	702	1	9600	0.510	101	1.4
24	703	1	9600	0.400	66	1.2
25	706	1	4800	0.669	120	3.2
26	706	1	4800	0.629	110	2.9
27	716	1	9600	0.391	25	1.2
28	422	9	2400	0.694	0	6.2
29	308	16	1200	0.563	130	7.5
30	302	25	1200	0.403	281	7.6
31	84	16	1200	0.662	188	8.0
32	74	18	1200	0.695	222	8.3
33	704	1	9600	0.355	0	1.2
34	707	8	1200	0.330	40	6.2
35	709	1	4800	0.455	0	2.2
36	712	6	1200	0.602	108	6.9

Table 12-27. Compilation of Cost and Performance Data for Ohio New or Improved Networks

Option		1	2	3	4	5	6	7	8
Network		1 Region	2 Region	3 Region	4 Region	LEADS BMV	LEADS and BMV	LEADS New Data	LEADS and New Data
Item	Parameter								
1	One-Time Cost ($K)	1.6	1.9	2.1	2.4	1.7	1.6	1.7	1.7
2	Eight-year Recurring Cost ($K)	6.4	7.6	8.8	10.1	7.93	7.9	7.0	6.9
3	Main Response Time (sec)	7.5	7.3	7.5	6.9	7.5/ 5.3	7.3	7.5/ 14	8.6
4	Availability	0.988	0.982	0.982	0.982	0.988	0.988	0.988	0.988

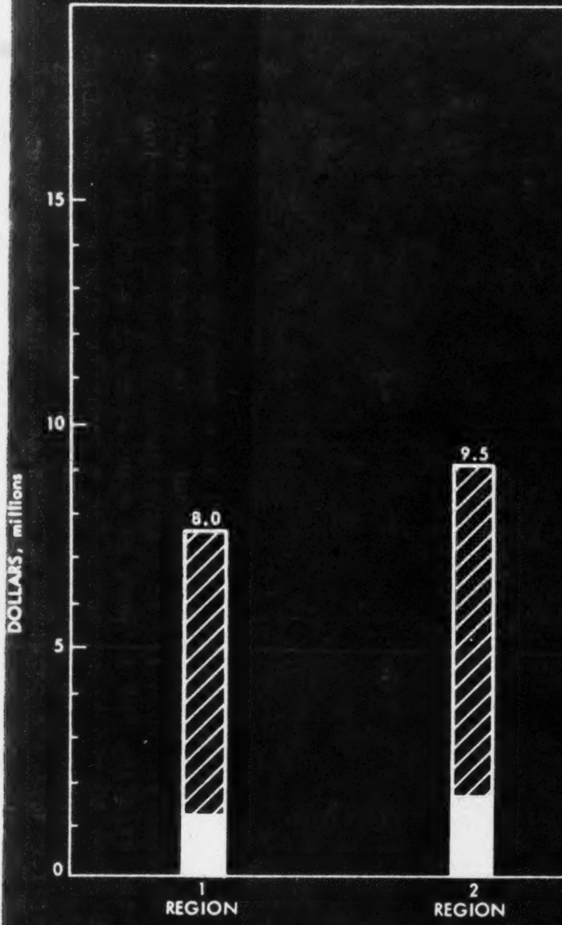
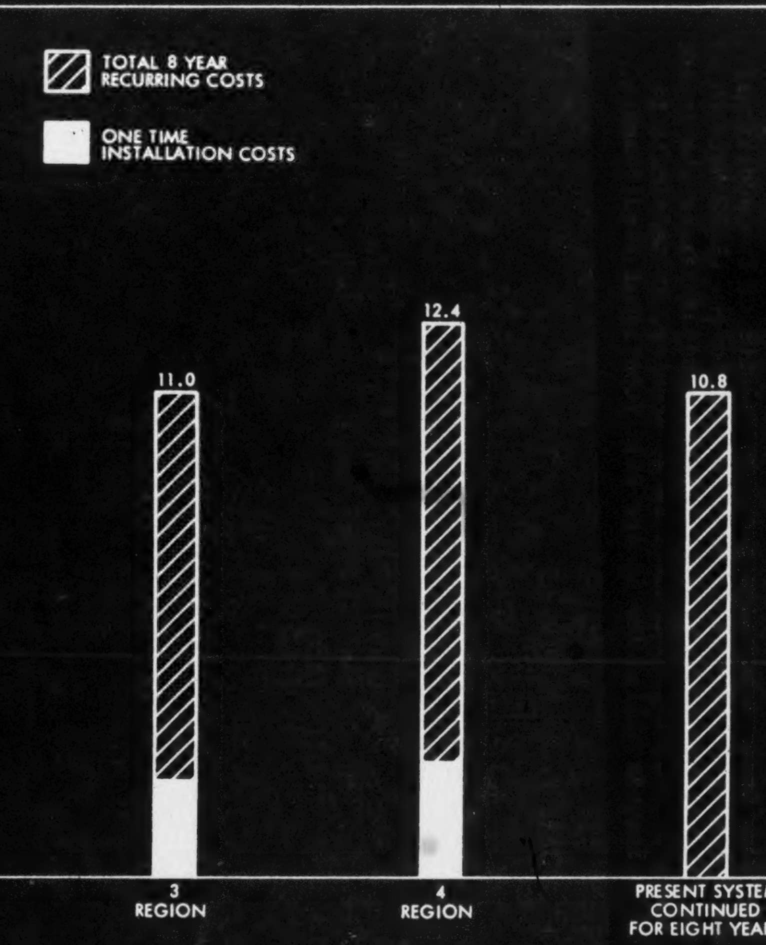


Figure 13-1. To
1



tal Cost -- 1978 Through 1985 Options
Through 4 and Present System

integrated network with the entire network subject to the interstate MPL tariff outlined in Section 9.

The figures indicate that total eight-year costs are not appreciably different. For example, referring to Figure 13-2, the to eight-year cost for separate networks is:

1.73 + 8(.991) = $9,658,000

and for the integrated case:

1.60 + 8(1.0) = $9,600,000

The figures indicate an eight-year savings estimate of $58,000.

It is evident that the use of different tariff structures plays an important role in the final costings of the two alternatives. would be reasonable to assume that a more substantial cost saving woul realized by combining two such state-wide networks if the same tariff used in all cases. However, as long as the networks in question are subject to the tariff structures assumed in this study, it would appea that cost is not an overwhelming consideration to the management decis to integrate or not to integrate the two networks.

This is not the case, however, if the LEADS and BMV networ could be integrated under the intrastate tariff used for BMV alone. A separate investigation of this possibility was carried out. In this c annual line costs would amount to $530,000 and line installation costs would be $72,000. Substituting these line costs, into Table 12-19, to network annual recurring and installation costs (including terminals a engineering costs) would be $764,000, and $1,600,000 respectively. Th yields an eight year total cost of

1.6M + 8 (764K) = 7.712M

This represents a meaningful savings of $1,940,000 over the separate L and BMV network, option 5.

13.3 SEPARATE VS INTEGRATED LEADS/NEW DATA NETWORK(S)

Whether integrated with the LEADS Network or not, the estimated growth of new data types from the present until 1985 calls for the implementation of 11 terminals through 1980, and the addition of 5 more terminals in 1981, for a total of 16 operational terminals from 1981 through 1985. This means that in each case there is a small additional one-time installation cost incurred in 1981. Figure 13-3 depicts these cost comparisons for the separate and integrated network cases. The family of bar graphs to the left shows that the LEADS and new data type networks taken separately require a total present install ation cost of $1.66M and a total annual recurring cost of $840K through the year 1980. The 1981 upgrade requires a $77K investment and recurri costs increment to $885K. The family of bar graphs to the right of

STACOM/OHIO NETWORK COMPARISONS

This section provides a comparative overview of the eight STACOM/OHIO Network Options and also presents results of two additional studies. One additional study deals with impacts on the LEADS Network of the inclusion of fingerprint data, and a second study assesses the impact on network costs of reducing response time as required at terminals to less than the 9 seconds called for in the OHIO Functional Requirements.

13.1 COMPARISON OF THE FOUR LEADS OPTIONS

Each of the four LEADS options, Options 1 through 4, involvin the use of from 0 to 3 regional switchers in addition to the existing Columbus switcher data base computer, have been designed to meet or excee the STACOM/OHIO functional requirements. The principal issue of comparison between networks thus becomes cost. Costs presented here, and in the previous Section 12, are based upon total eight year installation and recurring costs for the years 1978 through 1985 as discussed in Section 4.

Figure 13-1 presents total eight-year costs for Options 1 through 4 and also includes eight-year costs for continuation of the present system for comparative purposes only. The single region LEADS Network is the cheapest. The two, three and four region options follow i order. These results show that line savings due to the use of regional switchers located throughout the state do not offset the additional costs incurred for regional switcher hardware, sites, personnel, interregion lines and increased engineering costs.

Since all networks meet functional requirements, the conclusion is that the STACOM/OHIO single region network is the most cost-effective option of the first four options.

13.2 SEPARATE VS INTEGRATED LEADS/BMV NETWORK(S)

The least cost LEADS network derived from Options 1 through 4 the single region case, was used to compare costs of separate vs integrated networks for LEADS and BMV traffic.

In considering the BMV network as a possible separate entity, network optimization was carried out subject to the intrastate tariff presented in Section 9. This led to a considerable annual recurring cost savings over the existing BMV network of approximately $100,000. When this value is added to recurring costs for a separate single region LEADS network, (which is subject to the interstate MPL tariff), a total annual recurring cost for separate networks is obtained. This value together with the total of one-time installation costs for each network is displayed in the left-hand portion of Figure 13-2. The bars to the right show one-time installation and annual recurring costs for an integrated

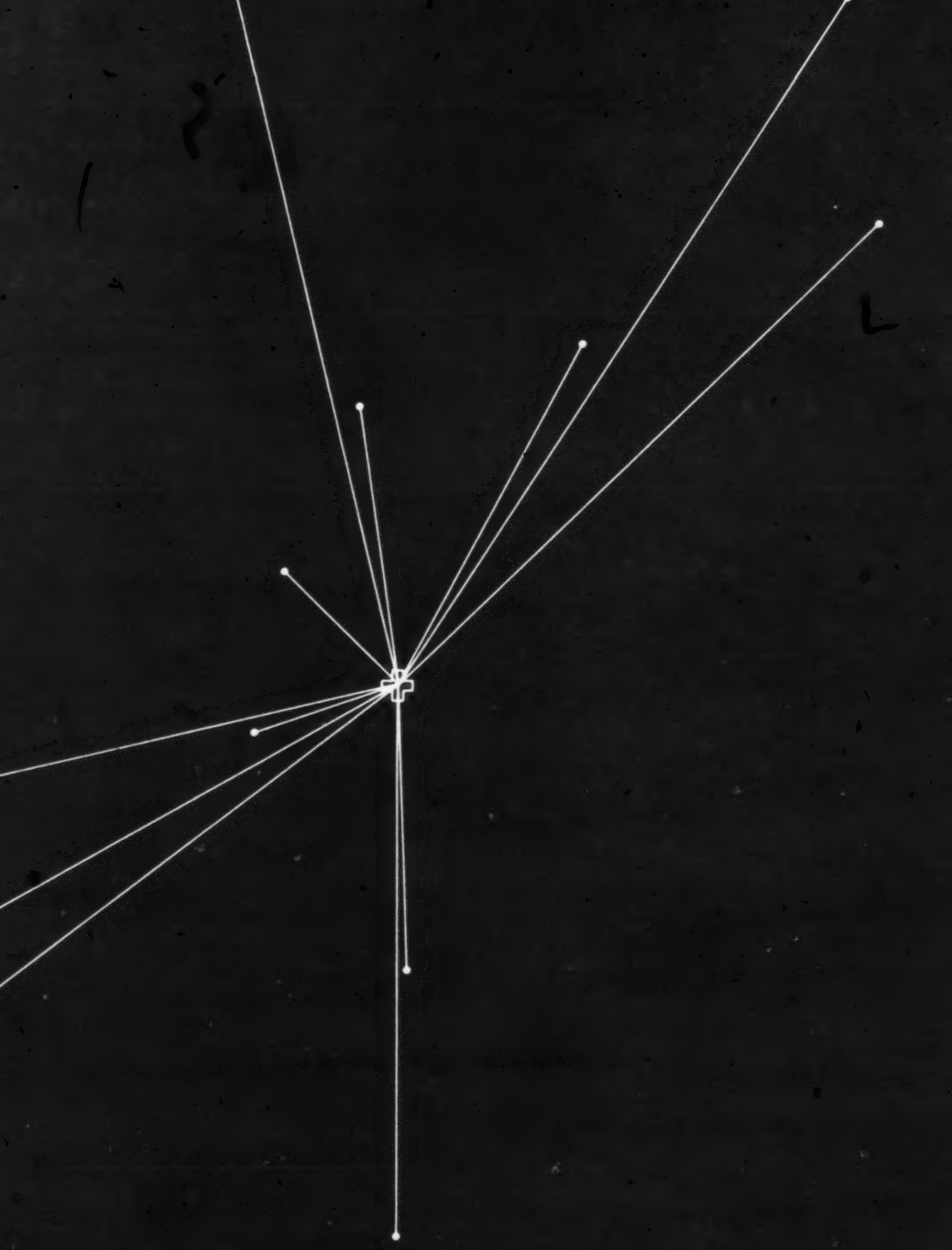


Figure 12-8. New Data Network after 1981

2) Please provide the information requested below regarding you state criminal justice information system.

	1971	1972	1973	1974	1975	1976
Number of Records in						
File Type 1						
File Type 2						
.						
.						
.						
.						
.						
.						
.						
.						
.						
.						
.						
.						
.						
.						
.						
.						
.						
File Type N						

3) Please supply past traffic volume data covering the period 1971 to the present. These traffic statistics should be broken out by user agency and message type.

Table 13-2. Cost Summary by Year for LEADS Network with Fingerprint Data ($1000's)

Year(s)	Item	No. Reqd.	Annual Cost Each	Total Annual Cost	Eight Year Re-curring Cost	Unit Cost	Total Pur-chase Cost
1978-1985	Lines	-	-	564	4,512	-	42
	Leads Terminals	390	0.6	234	1,872	3.6	1,400
198 - 1985	Lines*	-	-	1.5	7.5	-	0.25
	Fingerprint* Terminals	1	12	12	60	200	200
1983 - 1985	Lines*	-	-	7.5	22.5	-	1.25
	Fingerprint* Terminals	5	12	60	180	200	1,000
Totals					6,654		2,643
Total Eight-Year Cost							$9,297

*Added costs in years shown

13.4.3 Performance

The principal performance question of interest when considering the addition of messages with long average message lengths, such as fingerprint data, to the LEADS Network is the potential degrading effect on response times for higher "priority" type messages involving officer safety.

An analysis of the mean and standard deviation of message service times on the LEADS Network with fingerprint data added, indicates that mean response time goals specified in the OHIO Functional Requirements will be met satisfactorily without the necessity of message blocking or message prioritization by the computer.

This result stems from two considerations. First, the classification of fingerprint data allows for substantial reductions in the actual amount of data characters transmitted for each fingerprint (1852 characters). Second, while this message length is still comparatively long with respect to the normal LEADS message types, the

16. SJIS: Final Report (Phase I), Technical Report No. 12, SEARCH Group, Inc., Sacramento, Calif., June 1975.

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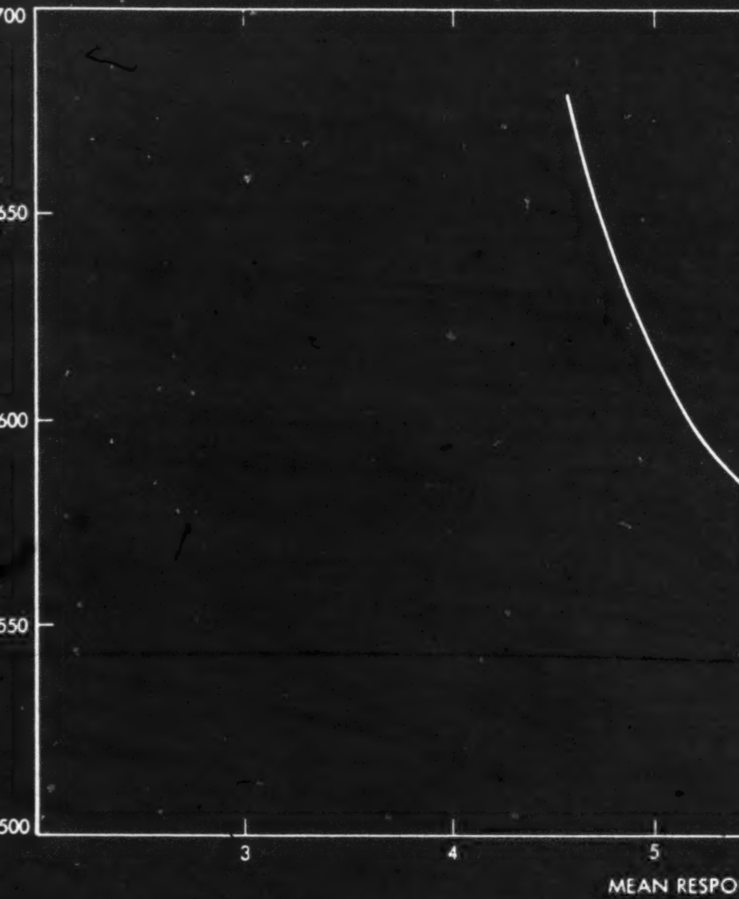
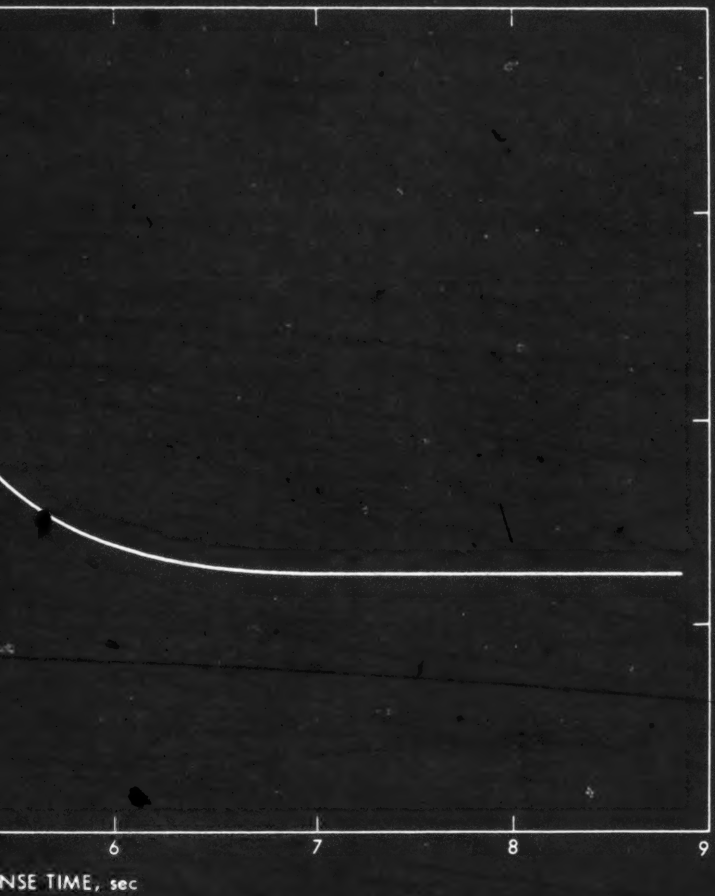


Figure 13-4. Recurring Line



Costs vs Mean Response Time

SECTION 14

REFERENCES

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3.2 National Criminal Justice Telecommunications Requirements, JPL Report 1200-133, Rev. A, June 28, 1974.

3.3 Joseph P. Martino, Technological Forecasting for Decisionmaking, American Elsevier Publishing Company, Inc., New York, 1972.

3.4 N. R. Draper and H. Smith, Applied Regression Analysis, John Wiley & Sons, Inc., New York, 1966.

APPENDIX A

STACOM PROJECT
STATE LEVEL QUESTIONNAIRE

1) Please provide one diagram showing principal components used in information interchange between all criminal justice user agencies. Principal components are defined as:

▭ Data Bases

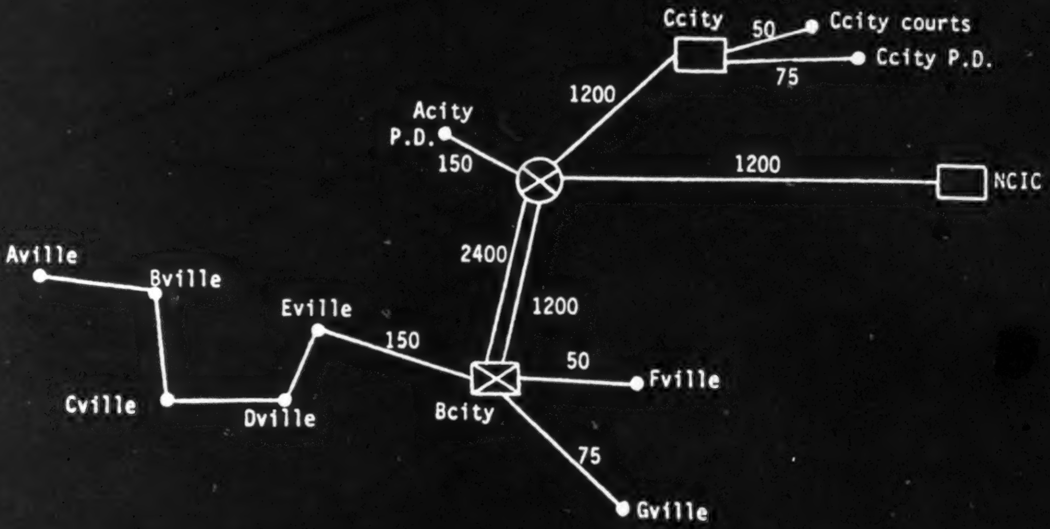
⊗ Switchers/Concentrators

⊠ Data Base and Switcher

•— Terminal(s)

— Line

Please include line sizes in bauds. For example:


Ccity
50
Ccity courts
Ccity P.D.
75
1200
Acity
P.D.
150
1200
NCIC
Aville
Bville
2400
Eville
1200
150
50
Fville
Cville
Dville
Bcity
75
Gville

Please indicate system upgrades that have occurred since January 1971 and indicate when they have occurred. Also, please indicate system upgrades that are planned for the future. Make separate diagrams if necessary.

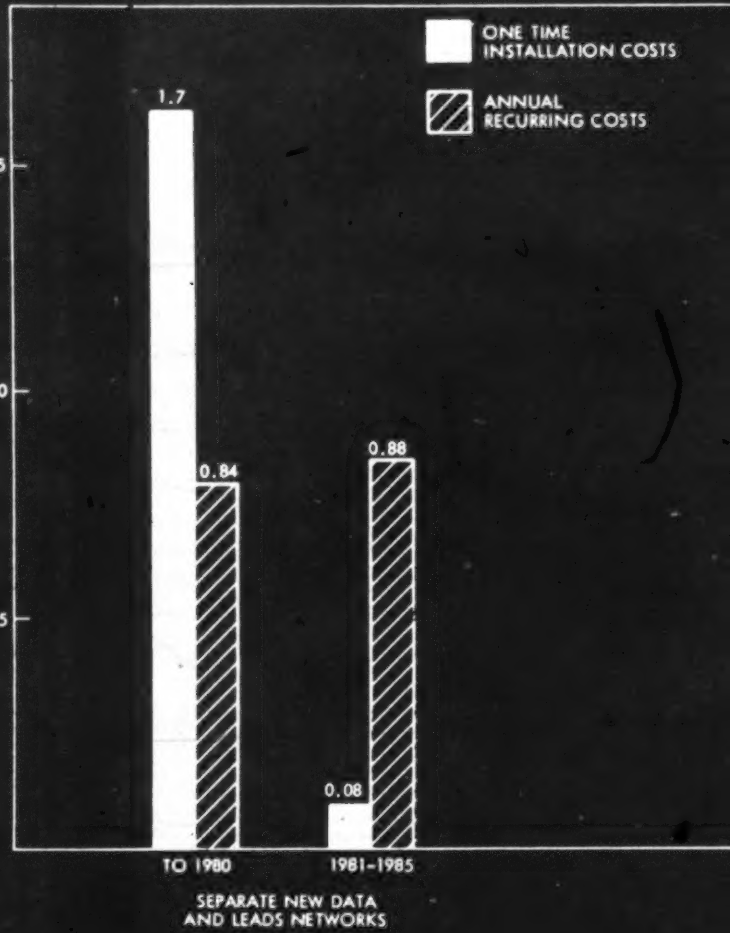
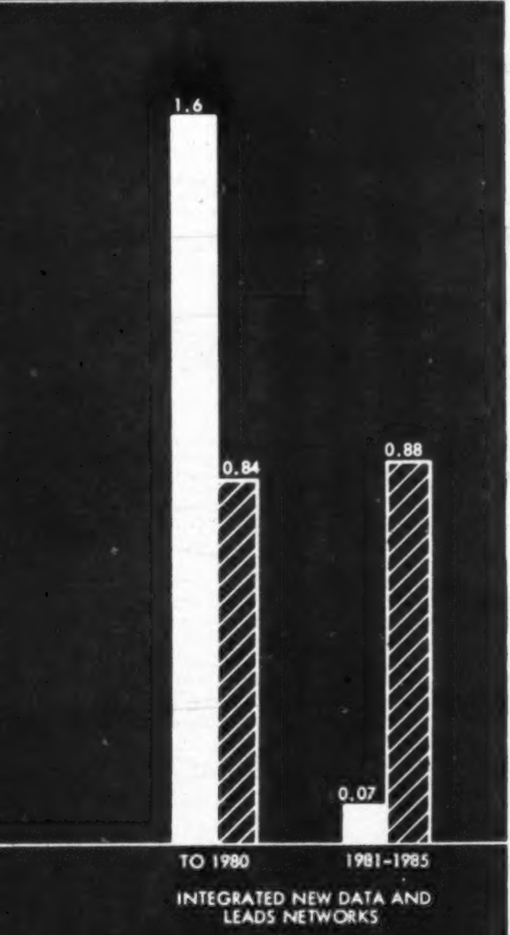


Figure 13-3. Separate vs Integrate



d New Data and Leads Network

a) Please provide format details for all message types transmitted over your state criminal justice communications system.

b) Please provide average message lengths by message type.

) Please provide an origin and destination matrix showing yearly message volumes from each user agency to each other user agency in your state.

Table 13-1. Network Line Characteristics

Network LEADS with Fingerprint Number of Regions 1
Remarks Columbus as Regional Center

Line No.	First Node	No. of Terminals	Line Type (Baud)	Line Utilization	Total Mileage (mi)	Mean Response Time (sec)
1	416	9	1200	0.160	145	5.3
2	355	25	1200	0.677	212	8.0
3	95	25	1200	0.502	195	7.3
4	146	5	2400	0.678	66	5.8
5	343	24	1200	0.517	183	7.3
6	323	3	4800	0.458	101	2.2
7	13	5	4800	0.389	120	2.0
8	116	17	1200	0.662	159	7.3
9	383	25	1200	0.538	256	7.4
10	64	5	1200	0.123	192	4.9
11	54	6	4800	0.693	126	3.2
12	44	25	1200	0.672	186	7.9
13	229	22	1200	0.589	188	7.4
14	408	21	1200	0.492	158	7.0
15	385	23	1200	0.497	190	7.1
16	43	4	2400	0.562	110	4.5
17	400	25	1200	0.573	184	7.5
18	370	7	1200	0.213	40	5.3
19	422	9	4800	0.536	0	2.4
20	308	20	1200	0.417	181	6.7
21	302	25	1200	0.405	281	7.0
22	84	16	1200	0.665	188	7.2
23	74	18	1200	0.698	222	7.5

Total eight-year costs are $9,298,000. Costs for lines, odems, and service terminals, (listed as LINES in Table 13-2), account for bout 3% of the eight-year cost increase over the single region LEADS ithout fingerprints and the costs for fingerprint processing equipment ccounts for 97% of the additional cost.

As indicated in Table 13-2, the purchase cost for a single ingerprint encoder-classifier is estimated at $200,000 per unit. Annual aintenance is assumed to run at $12,000.

the two networks are integrated into a single
ntity.

Assuming that network implementation takes place in 1978, then
he life of either network before upgrade is three years to 1980, and the
ife of the upgraded network is five years. The total eight-year cost
stimate for the case where the networks are separate, then becomes:

$$1.66 + 3(.840) + 0.077 + 5(0.885) = \$8,682,000$$

nd the total eight-year cost for the integrated option is

$$1.62 + 3(.840) + 0.072 + 5(0.882) = \$8,622,000$$

or an eight-year estimated difference of $60,000.

As in the case of considering BMV/LEADS integration, the
onetary benefits of integration are not significant when compared to
otal cost. The reason, however, in this case is not due to tariff
tructures but is due to the fact that there are so few new data type
ines in comparison to LEADS lines.

Both networks function within specifications of STACOM/OHIO
etwork functional requirements. The conclusion, therefore, is that cost
onsiderations alone do not represent a significant factor in the man-
gement decision to implement Options 7 or 8.

3.4 IMPACT OF FINGERPRINT DATA ON LEADS NETWORK

3.4.1 Topology

Predicted growth of fingerprint data types is contingent on
he development and use of encoding and classifying equipment located in
ajor Ohio cities. The implementation schedule calls for a first digi-
izer classifier to be located in the Cleveland PD in 1981 and five more
o be added to the system in 1983 at PDs in Columbus, Cincinnati, Toledo,
ayton and Akron. The incorporation of these facilities involves a slight
odification to the topology of the single region LEADS case, (see
aragraph 13.1). The LEADS Network with fingerprint data added as
pecified requires a total of 23 multidropped lines. These lines, and
heir principal characteristics, are summarized in Table 13-1.

.4.2 Costs

Total eight-year costs for a LEADS Network which handles
ngerprint data are broken down in Table 13-2. Costs for the LEADS
etwork from 1978 to 1985 are shown separately. In 1981, the increment
sts for the first terminal in Cleveland are shown. These costs are
curred through 1985. The three-year costs for the addition of the final
ve terminals in 1983 through 1985 are also listed.

For these reasons, the mean response time goal of less than equal to 9 seconds is met for the network topology presented in Paragraph 13.4.1.

8.5 NETWORK COST SENSITIVITY TO RESPONSE TIME

The effect of reducing network response time requirements on annual recurring costs for lines, modems and service terminals in the single region LEADS case, (Option 1), was investigated. Network optimization computer runs were carried out at a number of points where the required response time was set at less than 9 seconds. The program then found the required networks and produced costs for each run.

Figure 13-4 shows the results of this analysis, which was carried out with the same mean service times for the Columbus computer to clarify the effect on network costs. The figure shows that for the OHIO single region LEADS Network, there is virtually no cost penalty for specifying a response time down to approximately 7.0 seconds. Stating the case alternatively, a network that meets a 9.0 second response time requirement also meets a 7.0 second requirement.

A slight increase in cost begins to appear at 6.0 seconds, due primarily to the reduction of the number of multidropped terminals on some of the lines. This reduction is required to meet the lower response time goal.

A substantial increase in cost of about 13% is required to realize a reduction in response time from 6.0 to 5.0 seconds. Reductions in mean response time below 5.0 seconds result in rapidly increasing costs.

The curve suggests that mean service times at network terminals in the neighborhood of 4 seconds would require substantial expenditures in the Columbus computer.

1. An Analysis of Automated and Semi-Automated Systems for Encoding and Searching Latent Fingerprints, Technical Memorandum No. 9, Project SEARCH, Sacramento, Calif., March 1974.

2. Annual Report of Texas Judicial Council, Texas Judicial Council, Austin, Texas, Annual.

3. Biomedical Computer Programs, University of California Press, Berkeley and Los Angeles, Calif., 1975.

4. Bright, James R. and Schoeman, Milton E. F., A Guide to Practical Technological Forecasting, Prentice Hall, Inc., Englewood Cliffs, New Jersey.

5. Crime in the United States - Uniform Crime Reports, FBI, U.S. Government Printing Office, Washington, D.C., Annual.

6. Criminal Justice Models: An Overview, NILECJ, LEAA, U.S. Dept. Of Justice, Washington, D.C., April 1976.

7. Directory of Automated Criminal Justice Information Systems, U.S. Dept. of Justice - Law Enforcement Assistance Administration, Dec. 1972.

8. Draper, N. R., and Smith, H., Applied Regression Analysis, John Wiley & Sons, Inc., New York, 1966.

9. Felkenes, George T. and Whisenand, Paul M., Police Patrol Operations, McCutchan Publishing Corporation, Berkeley, Calif., 1972.

10. Martino, Joseph P., Technological Forecasting for Decisionmaking, American Elsevier Publishing Company, Inc., New York, 1972.

11. National Criminal Justice Telecommunications Requirements, JPL Report 1200-133, Rev. A., June 28, 1974.

12. OBSCIS: The OBSCIS Experience, Technical Report No. 16, SEARCH Group, Inc., Sacramento, Calif., Nov. 1976.

13. OBSCIS: Volume 1, The OBSCIS Approach, Technical Report No. 10, SEARCH Group, Inc., Sacramento, Calif., May 1975.

14. Ohio Courts Summary, Ohio Administrative Director of Courts, Columbus, Ohio, Annual.

15. Report on Latent Fingerprint Identification Systems, Technical Memorandum, No. 8, Project SEARCH, Sacramento, Calif., March 1974.

7) Please indicate any planned upgrade that would affect tra against current law enforcement files. Examples are:

a) Increase the number of records in file.

b) Reduce response times.

c) Increase the number of law enforcement users.

END

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The following is a list of 'new' data types

- computerized criminal histories - already in service
- offender-based transaction statistics (adult and juveniles)
- criminal court audit and management systems
- criminal justice planning information
- criminal intelligence data
- crime lab data including facsimile transmission, bibliographic exchange, firearm identification and spectral analysis
- corrections agency data systems (for management, training, education and rehabilitation which includes parole, probation, and corrections departments)
- criminal extradition and rendition system
- prosecutors management information system
- automated legal research
- video applications (including training, courts and corrections)
- digital mug shot identification
- digital fingerprint transmission
- boat registration file maintained by Parks and Wildlife Dept.

Include in this list others you are aware of.

In your answers to questions 2) and 3) you have supplied us with information concerning data base characteristics and message volumes for the above 'new' data types already implemented on your state telecommunication system. For each of these already implemented new data types:

1) Do you plan to increase the number of records contained in the data files? If yes please discuss the phasing of this increase.

2) Will the number of users participating in the exchange of these new data types increase? If yes, please identify the new users.

) With respect to each of the 'new' data types in the list above which you have not yet implemented.

1) Is implementation planned? If yes

2) What is the time phasing?

3) What agencies will use it?

4) Which facilities will maintain data bases with this data type?

5) Is any state agency studying or testing the feasibility of one of these data types? If so, describe.

) With respect to all of the above new data types, are you aware of, or are you using, any new or recent commercial product or service which is specifically tailored to acquire, process, or display this data type. An example might be a special purpose fingerprint analysis and display terminal which sends and receives digitized fingerprint data.

a) Please identify either federal or state privacy and security legislation that currently has an impact on the criminal justice information system, with regard to such things as data file update intervals, encryption requirements, personnel identification at the terminals, dedicated vs. shared systems, fingerprints supporting each file, etc. Please characterize these impacts.

b) Are you aware of planned privacy legislation that will impact criminal justice information systems? If yes, please characterize these impacts.

0) Please identify administrative and legislative constraints to system development.

1) Regionalization within your state.

2) Requirements to utilize existing state equipment.

Please provide the following court statistics.

1) Number of courts by type.

2) For each court type.

Number of Yearly Filings by Case Type

a) Case Type/Year	1972	1973	1974	1975

Number of Dispositions by Case Type

b) Case Type/Disposition, e.g.,	Conviction	Acquittal	Lesser Charge

3) Are there factors in the future that are likely to change these statistics?

   a) Normal Growth

   b) Decriminalization

   c) Administrative Changes

   d) Etc.

3) Interrelationships between state criminal justice agencies which may impede development of an integrated criminal justice telecommunication system.

4) Budget limitations

Are there other innovations or planning activities in the state that would aid us in predicting traffic levels? Examples are:

a) Are you in contact with and aware of the local Bell System operating company's (or other common carrier's) planning activities for your state? If so, please describe.

b) Are you in contact with the State Public Utilities Commission and maintain currency with their decisions on state tariffs and other related communication matters? If so, please explain the nature of your contact.

c) Can you provide descriptive material of the state's organizations dealing with telecommunications in general, and criminal justice telecommunications in particular?

Has a criminal justice flow model been prepared that describes the offender's progress through your state's criminal justice system?

Has the information needed to perform functions in the above flow process been identified? We are specifically interested in information that could be transmitted over the state criminal justice information system.

Please provide information on the number of criminal justice agencies in your state by agency type.

Agency Type	Number
Law Enforcement	
Courts	
Corrections	

STACOM PROJECT
USER AGENCY SURVEY

USER AGENCY ______________________________

ADDRESS ______________________________ DATE ______________

______________________________ RESPONDENT ______________

PHONE ______________

AVG. NO. OF MSG. SENT/DAY ______________________________

AVG. NO. OF MSG. RECEIVED/DAY ______________________________

NO. OF MSG. SENT DURING PEAK HR ______________________________

CURRENT AVERAGE RESPONSE TIME* (sec) ______________________________

ACCEPTABLE RESPONSE TIME (sec) ______________________________

PERCENTAGE DOWN TIME ______________________________

Please fill out as much as you can in the following table for the population area served by your terminal.

	1975	1974	1973	1972	1971
Crime Rate per Capita**					
Number of Personnel Requiring Info. over State C.J. Telecommunications System					

*Your best estimate of average response time. Response time is defin as time from the moment you request the network to take a message un a satisfactory reply is completed at your terminal.

**Includes crimes falling in the U.C.R. seven major crime categories. Murder and non-negligent manslaughter, forcible rape, robbery, aggravated assault, burglary - breaking or entering, larceny [illegible] aut theft.

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